More facilities seem a major concern at the state parks (Boston six) and the Lake Washington sites (Seattle two), and at the former there was some clear desire for cleaner facilities as well. About 20 percent of the sample could make no suggestions. To an extent this appears to be another clear effect of high quality. And note that only 10 percent gave this response at Boston three sites---the in-city beaches where 71 percent wanted some form of cleanup.

To explore the determinants of these attitudes we crosstabulated income with reasons for site choice in Boston and Seattle (Table II.56 and II.57) and with preferences for site improvement (Table II.58 and II.59). When it comes to preferences for site choice, in both cities convenience is given as a reason in about the same percentage of cases in all income classes. (The percent-in the over $25,000 class is a bit less). This is interesting in view of the relationship between distance traveled and income. The cleanliness or other characteristics of the area is also advanced as a reason in about the same fraction of cases at different income classes. This is unusual in view of differences in site use and preferences for site improvement---reported below. Social/family reasons are a bit more likely at lower income levels and the assertion of random choice is more common at higher income levels (16 percent of those above $20,000 and 7 percent of those under $7,500 offered this reason in the Boston survey while 12 percent of those in between these income levels did so).

When we explore preferences for site improvement, we find that lower income classes are somewhat more likely to ask for cleanup than

Table II.56

CROSSTABULATIONS OF INCOME WITH REASONS FOR SITE CHOICE: BOSTON RECREATION SURVEY

INCOME	CONVENIENT	CLEAN WATER	CLEAN BEACH	FACILITIES/ AREA	UNCROWDED	SOCIAL/ FAMILY	WATER CHARACTER- ISTICS	RANDOM	OTHER	HABIT OR MEMORY	ROW TOTAL
0 to 5000	51	5	4	7	4	13	9	10	3	4	110
5000 to 7500	44	4	4	5	6	8	1	4	2	2	80
7500 to 10000	73	22	7	15	1	21	7	19	4	5	174
10000 to 12500	83	7	9	9	4	25	11	14	2	4	168
12500 to 15000	80	14	2	8	6	18	8	23	10	2	171
15000 to 20000	64	6	7	14	5	11	6	19	2	2	136
20000 to 25000	37	3	8	5	1	5	3	10	1	3	76
Over 25000	29	2	2	8	2	4	3	13	5	1	69
Column Total	461	63	43	71	29	95	58	112	29	23	984

Table II.57

CROSSTABULATIONS OF INCOME WITH REASONS

FOR SITE CHOICE: SEATTLE RECREATION SURVEY

Income	0-5000	5000-7500	7500-10000	10000-12500	12500-15000	15000-20000	20000-25000	Over 25000	Row Total
Convenient	29	10	25	16	13	11	8	7	119
Clean water	2	2	0	0	1	1	0	0	6
Clean beach	0	1	1	1	2	1	1	0	7
Facilities/area	6	3	10	8	3	6	1	7	44
Uncrowded	4	0	2	6	2	5	2	0	21
Social/family	6	0	1	5	1	3	0	3	19
Water characteristics	3	2	1	3	2	2	2	1	16
Random	0	2	2	1	1	3	0	0	9
Other	1	1	0	0	1	1	0	0	4
Column Total	51	21	42	40	26	33	14	18	245

Table II.58

CROSSTABULATION OF INCOME WITH PREFERENCES FOR SITE IMPROVEMENT
BOSTON RECREATION SURVEY

Amount in Dollars	0 - 5,000	5,000- 6,500	7,500 - 10,000	10,000 - 12,500	12,500 - 15,000	15,000- 20,000	20,000 - 25,000	Over 25,000	Row Total
Preference									
Cleaner Water	22	18	28	22	21	19	14	4	148
Cleaner Beach/Litter	14	10	18	20	17	12	5	9	105
Cleaner Beach/Rocks	6	7	23	22	16	18	4	9	105
Warmer Water	2	6	1	5	3	2	4	2	25
More Facilities	15	7	13	29	23	18	8	4	117
Fewer Facilities	2	1	2	1	2	0	1	4	13
Fewer People	4	4	10	4	5	7	4	5	43
More Parking	4	4	2	9	4	3	3	5	34
No Dogs	2	1	0	5	1	0	1	1	11
No changes/ don't know	19	13	33	28	42	29	17	16	197
Bigger Beach	3	1	11	6	11	6	5	1	44
Cleaner Facilities	2	1	3	1	3	9	1	0	20
Other	6	3	12	4	10	6	7	5	53
Column Total	101	76	156	156	158	129	74	65	915
% Cleaner Water/Beach	41%	46%	44%	41%	34%	38%	31%	33%	
% No Changes/Don't Know	19%	17%	21%	18%	26%	22%	23%	24%	

Table II.59

CROSSTABULATION OF INCOME WITH PREFERENCES FOR SITE IMPROVEMENT:
SEATTLE RECREATION SURVEY

Amount in Dollars	0 – 5,000	5,000 – 6,500	7,500 – 10,000	10,000 – 12,500	12,500 – 15,000	20,000 – 25,000	20,000 – 25,000	Over 25,000	Row Total
Preferences									
Cleaner Water	3	0	2	3	2	2	0	0	12
Cleaner Beach/Litter	5	0	2	4	1	3	1	1	17
Cleaner Beach/Rocks	1	0	1	1	0	0	0	0	3
Warmer Water	1	0	0	0	0	0	0	0	1
More Facilities	9	4	7	6	7	6	3	4	46
Fewer Facilities	1	0	0	0	0	0	0	0	1
Fewer People	3	3	1	2	1	0	0	3	13
More Parking	3	2	2	2	1	0	1	1	12
No Dogs	1	2	1	1	0	2	1	2	10
No changes/ don't know	1	2	7	8	3	6	3	1	31
Bigger Beach	6	4	1	2	3	2	1	0	19
Cleaner Facilities	0	0	0	0	2	1	0	0	3
Other	1	1	7	3	1	2	0	3	18
Column Total	35	18	31	32	21	24	10	15	186

upper income groups (Table II.58 and II.59) and that conversely upper income groups are more likely to not have suggestions about how to improve the site they are using. Having done analagous crosstabulations for each of the Boston sites, and not found these difference, (which we do not repoduce for reasons of brevity) it seems apparent that these differences again are due to differences in site use. Upper income individuals tend to use the "better" sites.

Turning now to education and reasons for site choice, we find in Boston (Table II. 60) that convenience is again given as a reason in about the same frequency for all educational groups (e.g. 48 percent for high school degree or less 45 percent for those with college or higher degrees and 46 percent for those with some other post secondary education). When it comes to random choice we find 11 percent for high school or less 8 percent at intermediate education levels and 15 percent for college degree holders and above. Notice too that college students seem very oriented to convenience while high school students are less SO. There is little pattern in presentation of cleanliness as a reason, although the lowest education groups do tend to give this answer more than higher degree recipients and a good deal more than college and higher degree students. Again, this is ironic given that these groups tend to use poorer facilities. In Seattle the pattern is a bit different (Table II.61) and higher education level individuals do more frequently give cleanliness reasons for their choice of site. College and higher degree graduates in Boston cities are more likely to urge fewer people and facilities (12 percent) than those with high school degrees or less (4 percent). College and higher degree recipients in both cities are

Table II.60

CROSSTABULATIONS OF EDUCATION WITH REASONS

FOR SITE CHOICE: BOSTON RECREATION SURVEY

Education	K to 8	SOME HIGH SCHOOL	HIGH SCHOOL GRAD	SOME COLLEGE	OTHER POST SECONDARY	COLLEGE GRAD	HIGHER DEGREE	HIGH SCHOOL STUDENT	COLLEGE STUDENT	HIGHER DEGREE STUDENT	Row Total
Convenient	1	21	211	60	33	97	42	9	52	13	539
Clean Water	1	4	31	7	6	10	4	6	2	0	71
Clean Beach	0	2	11	8	3	15	3	5	0	0	47
Facilities/ Area	3	3	32	10	3	18	7	0	6	2	84
Uncrowded	1	1	11	6	3	5	3	0	0	0	30
Social/ Family	3	3	61	22	9	28	5	2	5	4	142
Water Char- acteristics	0	3	22	6	3	9	2	2	1	3	51
Random	6	2	47	10	7	32	14	2	7	2	129
Other	0	2	6	4	3	6	7	3	1	0	32
Column Total	15	41	432	133	70	220	87	29	74	24	1125

Table II.61

CROSSTABULATIONS OF EDUCATION WITH REASONS FOR SITE CHOICE: SEATTLE RECREATION SURVEY

Education	K to 8	SOME HIGH SCHOOL	HIGH SCHOOL GRAD	SOME COLLEGE	OTHER POST SECONDARY	COLLEGE GRAD	HIGHER DEGREE	HIGH SCHOOL STUDENT	COLLEGE STUDENT	HIGHER DEGREE STUDENT	Row Total
Convenient	2	3	22	10	2	23	8	23	29	3	125
Clean water	0	1	2	0	0	1	0	0	2	0	6
Clean beach	0	0	0	0	2	3	1	0	1	0	7
Facilities/ Area	0	1	16	4	0	7	1	4	9	2	44
Uncrowded	0	0	5	6	1	2	0	4	3	0	21
Social/ Family	1	0	3	1	0	6	2	6	2	1	22
Water characteristics	0	0	4	1	1	2	0	1	6	0	15
Random	0	1	6	0	0	1	0	2	0	0	10
Other	0	0	2	0	0	0	0	1	2	0	5
Column Total	3	6	60	22	6	45	12	41	54	6	255

Table II.62

CROSSTABULATION OF EDUCATION WITH PREFERENCES FOR SITE IMPROVEMENT:

BOSTON RECREATION SURVEY

Education	K to 8	Some H.S.	H.S. Graduate	Some College	Other Post-Secondary	College Graduate	Higher Degree	H.S. Student	College Student	Higher Degree Student	Row Total
Preference											
Cleaner Water	4	3	65	21	12	33	9	3	17	6	173
Cleaner Beach/Litter	1	7	57	10	9	14	8	3	3	3	115
Cleaner Beach/Rocks	0	2	39	13	8	30	6	7	16	2	123
Warmer Water	0	0	14	1	2	5	1	2	0	0	25
More Facilities	3	6	51	22	8	19	9	3	5	3	129
Fewer Facilities	0	0	2	1	1	5	5	0	0	0	14
Fewer People	0	1	15	4	3	19	5	0	2	1	50
More Parking	0	0	14	7	2	4	8	0	3	1	39
No Dogs	0	1	9	0	0	2	0	0	0	0	12
No Changes/ don't know	7	9	82	32	18	46	19	3	9	4	229
Bigger Beach	0	3	26	2	3	7	4	0	6	1	52
Cleaner Facilities	0	2	8	2	1	6	1	1	0	0	21
Other	0	2	13	5	2	18	7	2	7	1	57
Column Total	15	36	395	120	69	208	82	24	68	22	1039

Table II.63

CROSSTABULATION OF EDUCATION WITH PREFERENCES FOR SITE IMPROVEMENT: SEATTLE RECREATION SURVEY

Education	K to 8	Some H.S.	H.S. Graduate	Some College	Other Post-Secondary	College Graduate	Higher Degree	H.S. Student	College Student	Higher Degree Student	Row Total
Preferences											
Cleaner Water	0	0	4	0	1	2	0	2	4	1	14
Cleaner Beach/Litter	0	0	4	1	0	2	3	2	4	2	18
Cleaner Beach/Rocks	0	0	0	0	1	0	1	1	0	0	3
Warmer Water	0	0	1	0	0	0	0	0	0	0	1
More Facilities	0	2	8	6	1	10	3	6	11	0	47
Fewer Facilities	0	1	0	0	0	0	0	0	0	0	1
Fewer People	0	0	4	1	1	4	0	1	3	1	15
More Parking	0	0	3	0	0	2	1	2	4	0	12
No Dogs	0	0	5	1	0	3	0	0	1	1	11
No Changes/ Don't Know	1	2	12	2	0	5	1	3	6	0	32
Bigger Beach	0	0	5	0	0	1	1	5	7	0	19
Cleaner Facilities	0	0	0	0	0	1	0	2	0	0	3
Other	1	1	5	1	0	4	1	1	4	1	19
Column Total	2	6	51	12	4	34	11	25	44	6	195

also somewhat less likely to say "don't know/no improvement" than those with high school degrees or less. Considering that upper income people show the opposite pattern versus low income people, there is apparently and independent education effect.

II.4.4. Summary

This study leads to one major conclusion. This conclusion is that the distribution of the benefits of water pollution control will vary significantly depending upon the particular pattern of cleanup and what kinds of associated recreation facilities are provided. Our telephone survey revealed that over the middle-income ranges, the willingness to pay for environmental quality rises somewhat more rapidly than income. Similarly, our studies of municipal finance indicate that the state/local share of pollution control expenditures will be quite regressive in its distributional impact. Thus, the overall effect of the program, on various income classes, will depend significantly on the pattern of recreation benefits it generates.

We conducted a large study of water-based recreation users in both the Boston and Seattle metropolitan areas. This study showed that upper income and education users travel longer distances on average and use higher quality recreation sites. In particular, as a result, the lower income and education users more frequently complain about the quality of the sites they use. Furthermore, different income and education classes give convenience as a reason for site choice in about the same frequency. Together this all suggests that upper-income and upper-education users are in general willing and/or able to travel further to obtain higher quality recreation. Thus, if substantial recreation benefits are to be provided to lower income users, facilities--even if only of moderate quality--need to be provided at appropriately accessible "in-town" locations.

Appendix II.A

Income-Perception of Environmental Problems: Questionaire.

Income-Perception of Environmental Problems: Questionaire.

(Enter respondent's sex into running ratio balance; if unbalanced, request opposite sex by title and surname.)

Hello. I'm (name of interviewer). We are doing a public opinion survey to find out views on some current public issues. Do you have time to answer a few questions?

(If yes.) Thank you. Then we'll begin.
(If no.) Can I call again a a more convenient time?
(If still no.) Terminate interview. Describe on back.

1. In which three of the following areas would you prefer the government to place greater effort?

A		B		C	
Welfare	____	Education	____	Housing	____
Education	____	Health	____	Law & Order	____
Housing	____	Environment	____	Welfare	____
Environment	____	Law & Order	____	Education	____
Health	____	Price control	____	Health	____
Price control	____	World Peace	____	Environment	____
World Peace	____	Welfare	____	World Peace	____
Law & Order	____	Housing	____	Price control	____

2. Now, there has been a lot of publicity during the last few years about the environment and pollution.

Would you please tell me what you consider to be the most serious environmental problem? ____________________

3. Now I'm going to read out to you a short list of other environmental problems. I'd like you to pick the two that you consider to be the most serious: (omit respondent's "most serious problem," if present):

A		B		C	
air pollution	____	aesthetics, ugliness	____	trash, garbage	____
trash, garbage	____	food additives	____	noise	____
noise	____	water pollution	____	air pollution	____
aesthetics, ugliness	____	trash, garbage	____	food additives	____
water pollution	____	air pollution	____	aesthetics, ugliness	____
pesticides	____	pesticides	____	water pollution	____
food additives	____	noise	____	pesticides	____
other (specify)	____	other (specify)	____	other (specify)	____

4. It is certainly going to cost a lot to have a clean total environment.

Who do you think should pay ____________________

____
(Record verbatim)

(If government--probe) local ____ state ____ federal ____

Code: Government ____
Polluter ____
Other ____

5. How should they get the money? ______________________________

____

(record verbatim)

Code: increased prices ________
government subsidies _____
increased taxes ________
divert expenditures ______
fine/tax polluters ______

6. Whoever pays, some of the cost will likely be passed along eventually to the consumer or taxpayer.

Would you be willing to pay in order to have a cleaner, better total environment?
Yes____ (go to q. 7) No_____ (go to q. 8) d.k. ____ (Probe, go to q. 7)

7. (If yes.) If taxes were to be raised to cover the costs of improving the environment, how much a year would you be willing to pay in higher taxes?
less than $10 ____ $10-$50 _____ $50-$100 __ $100-$200 ____ more than $200 ____

8. (If no.) Why not? ______________________________

9. If recreational facilities were to be expanded or improved in the Boston area, which of the following would you prefer to see?
More swimming pools ____
More skating rinks _____
Cleaning the Charles River so you can swim in it ____
More parks and playing fields ________

10. What ideas come to mind when you think of water pollution? (Probes: What is it? How would you describe it?) ______________________________

____

(record verbatim)

11. Do you think the Charles River is polluted?
yes_____ (go to q. 12) no_____ (go to q. 14) d.k. ____ (go to q. 14).

12. Do you think the Charles River ever will be cleaned up?
yes __ (go to q. 14) no_____ (probe below) d.k. __ (go to q. 13)
(If no, probe for reasons) Political____ Economical____ Technical_____ (go to q. 14)
Human nature ____ other _____

13. Do you think the Charles River ever could be cleaned up?
yes __ no ___ d.k. ____

14. How would you react to the following statement:
"I feel that my concern has very little influence on the amount of pollution in this area, and that such interest as I have doesn't do any good."

strongly agree _____
agree _____
indifferent _____
disagree _____
strongly disagree _____

Now, just a few questions about yourself to place our survey results into 3 statistical perspective.

15. Would you please tell me how old you are? _____ (Probe: Just indicate the range into which you fit: 0-20 ____ 21-20 ____ 31-40 ____ 41-50 ____ 51-60 ____ over ____)

16. How many members are there in your immediate family that are living with you now? (Including respondent.)

0 ____
1 ____
2 ____
3 ____
4 ____
5 ____
6 ____
over ____

17. Would you please tell me approximately what was your total family income last year? (Probe: Just indicate the range into which it falls:)

under 3000 ____
3-5000 ____
5-10,000 ____
10-15,000 ____
15-20,000 ____
20-25,000 ____
over ____

18. Would you please tell me what is your occupation? ______________________
(record verbatim)

19. And what was your highest level of education?

Code: higher degree ____ grade ______
college degree ____
some post-secondary ____
high school diploma ____
completed grade school ____

Well, that's about all. Thank you very much for your time and cooperation. You have been most helpful. Goodbye.

(Immediately after hanging up, record the following):

20. Sex of respondent: Male ____ Female ____.

21. Town of residence:

22. Date of interview: April____, 1973.

23. Time of interview: ______________ A.M. / P.M.

24. Interviewer:

Appendix II.B

Recreation Survey Questionnaire

RECREATION SURVEY QUESTIONNAIRE

Location________________ Time__________ Date _________________

How did you get here today? _______________ How many are in your group? ____________

How often have you used this site this year? ________ and last year? ________

Why do you come here? _____________________________

What other recreation areas do you use? ____

What changes in this area would lead you to come here more often? __________________

____

Could you tell me what town you live in? _____________________

What street do you live on? _________What is the closest cross street? _______________

How far did you go in school? ____________________________

What letter corresponds to your approximate family income last year? __________________

III. The Distribution of the Local Government Share of Water Pollution Control Costs: The Merrimack River

This study focuses on the distribution among income classes of water pollution abatement costs in the Merrimack River Basin, particularly those costs borne by local governments. Local expenditures on waste treatment facilities often constitute a relatively large share of the budget of those municipalities. The distributional effects may be quite substantial.

After a brief review of some of the characteristics of the river valley (Section III.1), we try to develop a model to help us predict inter-town variance in the level of water pollution abatement expenditures (Section III.2). This work was then used to help us to examine statistically in Section III.3 both the between-city and within-city distribution of local government expenditures.

III.1. The Study Area

The Merrimack River Basin is located in southeastern New England, chiefly in New Hampshire and the northeast corner of Massachusetts (see Figure III.1). It consists of the Merrimack River and its three major tributaries, the Nashua, the North Branch Nashua, and the Winnepesaukee Rivers. The Basin is 134 miles long and covers a land area of 5,000 square miles.

The Merrimack River Basin is primarily a manufacturing and service area; by 1970, only 1.2% of the total Basin population was still engaged in agriculture. Textiles, leather goods, machinery, paper and plastics dominate the area. The bulk of the industrial water pollution in the area is generated by six industries: pulp and paper, textiles, wool scouring, plastics, food processing and tanning.

The water quality along most of the Merrimack River and its tributaries is suitable only for power, navigation, transportation of sewage and wastes, and a limited number of industrial uses; the full classification of the basin recently done by the Army Corps of Engineers is given in Table III.1.

In response to the recent concern with the quality of the environment, and to the new federal water pollution legislation, a number of the municapalities in the Basin have begun to build new waste treatment facilities. A list of the municipalities in our study area and their current and proposed treatment facilities is given in Table III.2. Two major regional facilities are planned: the Greater Lawrence Sanitary District, and the Winnesesaukee Regional District.

The Merrimack River Basin consists of a number of middle-income towns. The median income for each of the towns is given in Table III.3. Many of the towns are quite small, with limited tax bases; thus, we would expect the distributional impact of the high expenditures required for sewage treatment to be fairly large.

III.2. Models of Local Government Behavior

Any model of the political decision process must begin by characterizing two basic dimensions of the political organization under analysis: the motivations of the actors within that organization

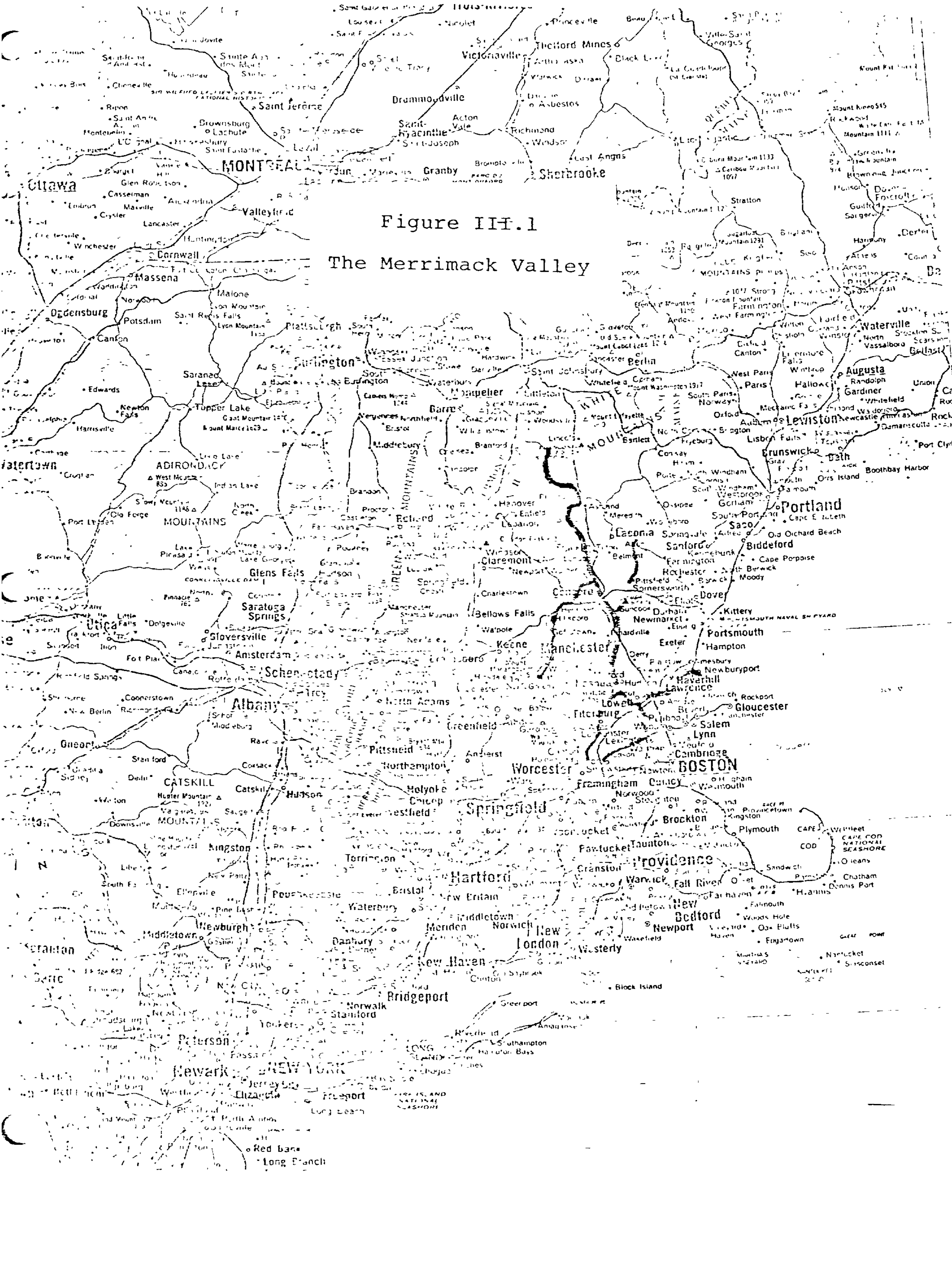

Figure III.1

The Merrimack Valley

TABLE III.1
PRESENT CONDITION OF THE MERRIMACK
RIVER BASIN AREA

River Mile From - To	River Beach From	River Beach To	Present Condition
0 - 11.80	Atlantic Ocean	Rocks Village Bridge Haverhill, MA	D & C
11.80 - 21.85	Rocks Village Bridge Haverhill, MA	Creek Brook Haverhill, MA	D & U
21.85 - 28.99	Creek Brook Haverhill, MA	Essex Co. Dam, Lawrence, MA	D & U
28.99 - 33.03	Essex Co. Dam, Lawrence, MA	Fish Brook, Andover, MA	D & U
33.03 - 40.60	Fish Brook, Andover, MA	Pawtucket Dam, Lowell, MA	D & U
40.60 - 47.35	Pawtucket Dam, Lowell, MA	Tyngsborough Bridge, Tyngsborough, MA	D & U
47.35 - 49.82	Tyngsborough Bridge, Tynssborough, MA	New Hampshire/Mass. State Line	D & U
49.82 - 54.80	New Hampshire/Mass. State Line	Merrimack R.(above conf. of Nashua R.)	C
54.80 - 68.05	Merrimack R. (above conf. of Nashua R.)	Goffs Falls, Manchester, NH	C
68.05 - 73.14	Goffs Falls, Manchester, NH	Amoskeag Dam, Manchester, NH	C
73.14 -115.70	Amoskeag Dam, Manchester, NH	Eastman Falls Dam, Franklin, NH (at conf. with Winnipesaukee R.)	C

Classification Key

A: Potentially acceptable for public water supply after disinfection.

B: Suitable for bathing, other recreational uses, agricultural uses; industrial processes and cooling; excellent fish and wildlife habitat; good aesthetic value; suitable for public water supply with appropriate treatment.

C: Suitable for fish and wildlife habitat; recreational boating and industrial processes and cooling.

D&U: Suitable for power, navigation and transportation of sewage and waste and certain industrial uses.

Table III.2: Current and Proposed Treatment Facilities in the Merrimack Valley

Area	Current Facilities	Proposed Facilities	Year of Fund Appropriations	Year of Project Completion
A. Lowell-Lawrence-Haverhill Area:				
1. Lawrence	(1) None (2) None	Secondary Interceptor GLSD		
2. Methuen	(1) None (2) None	Part of GLSD Part of GLSD		
3. Andover	Part None, Part Secondary	Part of GLSD		
4. N. Andover	None	Part of GLSD		
5. Haverhill	(1) None (2) None	Secondary Interceptor	1970 1970	1973 1973
6. Groveland	None	Lie to Haverhill	1970	1971
7. Lowell	(1) None (2)	Secondary Interceptor	1969 1972	1973 1975
8. Billerica	Secondary and Cl_2	Interceptor	1968	1970
9. Chelmsford	None	Secondary	1968	1973
Chelmsford Center	None	Secondary	1972	1975
10. Dracut	None	Secondary	1971	1974
11. Lewksbury				
B. Fitchburg				
1. Fitchburg	None	Secondary	1969	1973
2. Leominster	Secondary	Secondary		
3. Linenberg				
4. Westminster				

(continued)

(Table III.2, Concluded)

Area	Current Facilities	Proposed Facilities	Year of Fund Appropriations	Year of Project Completion
C. Nashua				
1. Nashua	(1) Part Primary	Primary & Interceptor	1971	1974
	(2) Part Primary	Secondary	1973	1975
2. Hudson	None	To Nashua	1971	1972
3. Merrimack	Secondary	Interceptors	1970	1972
D. Concord-Merrimack				
1. Concord (N)	None	Primary, Secondary	1971	1973
(S)	None	Secondary	1973	1973
2. Pembroke				
3. Bow				
4. Hooksett	Secondary			1970
5. Manchester	(1) None	Primary	1972	1973
	(2) None	Secondary	1974	1975
	(3) None	Interceptors	1973	1975
6. Bedford				
7. Goffstown				
E. Winnipesaukee Area				
1. Northfield				
2. Franklin, 3. Lilton, 4. Sanbornton, 5. Belmont	None	Secondary	1970	1972
6. Laconia				

Table III.3: Median Income of Towns in the Merrimack Basin

Town	Income
Lawrence	$ 7367
Andover	12730
North Andover	10249
Methuen	9739
Haverhill	7631
Groveland	11052
Fitchburg	7676
Westminster	10250
Lunenberg	10316
Lowell	7376
Dracut	10928
Tewksbury	11250
Chelmsford	13092
Billerica	10928
Leominster	8985
Nashua	9301
Merrimack	11384
Concord	7589
Bow	7500
Hudson	10596
Pembroke	8923
Hooksett	8683
Franklin	7523
Tilton	6843
Northfield	6800
Belmont	7000
Laconia	7696
Gilford	10720
Meredith	8022
Sanbornton	8000
Manchester	7500
Bedford	11677
Goffstown	6626
Hillsboro	7242
Hopkinton	10802
Plymouth	4470

and the opportunity set within which those actors operate. In this sense, the analysis of the state parallels much of the work done in economics on the theory of the firm.

Past work on political organizations has relied upon one of two metaphors as a description for the state: the adding machine and the single mind. A set of motivations and opportunities are implicit in each of these two models. In this section, these two basic metaphors of the state will be reviewed and extended; and the motivations and opportunity set implied by each defined. Then the predictions yielded by each of the models as to what determines inter-municipal variations in the level and financing of water pollution abatement programs will be considered.

III.2.1. The Traditional Approaches

The view that the state may be treated as a simple adding machine has a long history. The metaphor is perhaps best associated with the work of Buchanan,[1] Buchanan and Tullock,[2] and Downs.[3] In Buchanan's model, the state is individualistic, it acts strictly as "a set of processes or machine which allows collective action to take place."[4] Moreover, the need for this collective action, and therefore, the need for the state, arises only in the case of "public" or indivisible goods, where benefits accrue to all citizens without direct individual purchase of the good. In such cases, there is no way for the free market pricing system to register preferences. It is here that Buchanan's state intervenes, and acts to sum up all the utilities available from the production of the indivisible good and thus determine the optimal output of that good.

The adding machine model is implicit as well in much of the more basic theoretical work done on social welfare functions: Arrow, Bergson, Samuelson and others[3] all assume that government acts to maximize some function (here W) which depends upon only the utilities of the citizens in that community. The primary debate in this literature concerns only the form of the function W, that is, what tallying method should be used by the state machine.

Downs puts a human element into the theory by attributing motivations to those who run the state, i.e., politicians. Downs' politicians choose output of governmental goods in order to maximize their vote getting ability. However, inasmuch as votes are derived from the utility functions of voters, Downs' state too operates to maximize voter utility.

Within the context of the adding machine metaphor, the political science literature suggests two functional forms for the "social welfare function;" that is, two possible tallying methods for the machine.

In the first model, best associated with Duncan Black and later with Davis and Hinich[4], the politician maximizes a social welfare function which depends upon yes/no variables which indicates whether or not citizens approve of an action. Mathematically we can write this by saying the politician seeks to maximize

$$2.1 \qquad W = \sum_{V=1}^{n} V_i$$

where V_i is a different number for each citizen. It equals 1 for each citizen who approves and zero for each who does not. Trying to make the welfare function specified in 2.1 as large as possible will not in general be equivalent to maximizing the economist's usual welfare function, since this formulation takes no account of relative intensity of voters' preferences.

The interest group model provides an alternative specification still within the context of the adding machine metaphor. In this formulation, there are homogeneous aggregates of voters, each cluster of which cares only about some specific aspects of a policy. Perhaps the best application of this model to the political decision process has been the work of Dorfman and Jacoby.[5] Dorfman and Jacoby examine a hypothetical river valley. They attempt to develop a mathematical model to predict the level of expenditure that a postulated regional commission would require each of the polluters in the Bow Valley to make for pollution control. Three interest groups are represented: the two polluting towns and a canning industry. The commission members then make a decision by making a weighted comparison of the net costs of each alternative policy to each of these separate interests.

The interest group model, in some imperfect fashion, introduces intensity of preferences into the welfare function maximized by the politician. The linkage between preference intensity and influence is clearly imperfect. The power of a group clearly depends not only on how much members care, but also on the opportunities available to them to manifest these preferences. Keeping in mind this caveat, we can approximate the interest group model as a maximization by local politicians of a function of the form:

$$2.2 \quad W = \sum_i w\, U_i$$

where w is the weight attached by the politician to each group and reflects the ability of that group to make its preferences manifest.

In both the individual and the interest group models described above, the primary goal of the political actor may be viewed as political popularity. There is, however, a second model of the state which has received somewhat less attention in the economics literature. In this model, the politicians themselves have preferences which are not simply derivative from the voters' preferences. Governmental decisions then depend upon both voters' preferences and the independent preferences of the political actor.

In analyzing the "organic" model of the political decision process, it is useful to draw on the literature on the managerial theories of the firm, particularly the non-profit maximizing models of Williamson, Baumol and Marris.[6]

The dominant characteristic shared by all of these models is that they predicate that <u>under certain conditions</u> the firm may act in response to motivations other than profits. The more prominent motivations suggested are total revenue,rate of growth, managerial prerequisites, and laziness. Firms can respond to one or another of these alternative goals only insofar as the market in which they operate is less than perfectly competitive; where no market power exists, only a strict adherence to profit maximization goals will permit the firm to remain afloat. This points out the necessity of identifying the opportunity set of the actor as well as his motivations.

Consider now the extent to which these alternative theories of the firm may be applicable to a model of the decision process of government. In the model of the organic state, we posit instead a politician who formulates tax and expenditure policy in an attempt to maximize his own happiness $\hat{U}$ subject to a constraint on getting a reasonable number of votes--like the profit constraints in "managerial" firm models. This implies the following characterization of the political process, where $\hat{U}$ depends on the character of public output which we indicate by arbitrary variables a, b, c.

2.3 $$\max.\ \hat{U} = \hat{U}\ (a,b,c)$$

subject to

$$\sum_i V_i \geq Z$$

$$\sum_i U_i \geq Z$$

where Z represents some "acceptable" level of political popularity, perhaps the level at which the political actor just insures his reelection.

The analogy to the theory of the firm suggests that the ability of a manager to respond to other than profit motivations depends critically on the lack of competition in the political market place. Thus, this model implies that there is some truth in the oft-made political observation that two-party politics improves the representation afforded a community's citizenry.

What motivations for the political decision maker? We are concerned here with the motivations of the elected politician. While the career bureaucrat has many of the same incentives as the elected official, he has somewhat different opportunities and faces different constraints. Since the elected official, especially in local government, has ultimate budgetary power, we can concentrate on him (her).

In general, we would expect politicians (much like other people) to behave in ways to maximize their own power, salary, prerequisites, reputation and so on, all of which are closely associated with the size of the government budget controlled by the politician.[7] The analogies between this model of government decision making and Williamson's managerial firm are clear. In both cases, decision makers try to expand organizational output in order to enhance their own power, salary, etc.

There are thus four plausible models of local government decision making. Two adding machine-models, one focused on interest groups and one on pure democracy. The organic model likewise has two versions, depending on whether the politicians perceive the potential process as pure or group in form. In the next section of this paper, we will investigate the operational differences between these four model specification in the determination of the level and financing of water pollution control. Then we present some empirical work which tries to distinguish among the four models.

III.2.2 Implications of the Models of Government Decisions

We can return now to the original question: What are the determinants of the level and financing of local government expenditures on water pollution abatement?

A great deal of empirical work has been done trying to identify the determinants of interstate variance in the level of per capita government expenditures. In most of this work, there is no explicit characterization of the underlying decision process. The independent variables identified are, in fact, appropriate to both the adding machine and the organismic state models, to either interest group or pure democracy voting paradigms.

The earliest econometric work done in isolating the determinants of government expenditures was done by Fabricant in the early 1950's.[8] Fabricant, using 1942 data, explained 72% of the interstate variation in per capita government expenditures by the use of three variables: population density, urbanization, and per capita median income. High per capita incomes increase both the demand for public services and the supply of potential tax funds. Urbanization is similarly positive, albeit small: the price of supplying public goods as well as the taste for public versus private goods are somewhat higher in urban than in more rural areas. Finally, Fabricant finds a negative coefficient for population density, reflecting economies of scale in the production of public goods. All three of these variables influence government expenditures by helping to determine either the opportunities confronting the voter, or his utility function.

A number of economists subsequently attempted to improve Fabricant's R2 by introducing variables for education, previous expenditures, representative tax system yield or tax base, population growth, and per capita federal expenditures in the area.[9] Further improvements were made by changing the form of the equation from linear to log form.

The first four new variables introduced in these extensions of Fabricant are reasonable. Education could be an indicator of tastes. Previous expenditures also indicate something about tastes in an area while simultaneously identifying the existing tax burden. Tax base and population growth both represent proxies for the supply of new tax funds. Kurnow's use of per capita federal expenditures as an independent variable, however, is specious. Kurnow used as his dependent variable local + state + federal per capita expenditures. The use then of per capita federal expenditures, part of the dependent variable, as an independent variable leads to a misestimate of the relationship. It increases the R^2 without in any way increasing the true predictive value of the equation.

All of this work assumes that local governments have reasonable flexibility in expenditure policy. For sewage treatment plant construction, however, the real opportunity set of the decision maker is less clear-cut. It may well be true that federal and state legislation coupled with technical considerations (viz. waste level and flow, stream type) completely determine the level of expenditures required for water pollution control Demographic and economic variables will be irrelevant in this situation.

Furthermore, previous econometric work has concentrated on the inter-area variance in the level of total expenditures. Hence, in the long run higher expenditures are assumed to induce higher tax levels. In an analysis of a specific expenditure category, however, this linkage can no longer be assumed. Local governments can generate the requisite pollution expenditure by reducing other expenditures as well as by raising taxes. Thus the determinants of differences in the financing schemes used by various towns is of great interest, particularly for any incidence analysis.

Assume first that local governments control both the level and the financing of sewage treatment plant expenditures; subsequently, we will consider a model of constrained decision making in which only financing decisions are endogenous. We will discuss first the subset of variables which can be expected to enter into regressions predicated on all of the models. Then we will consider those variables unique to each of the alternative theories of the state.

Four separate sets of explanatory variables seem to account for intermunicipality variance in the level of per capita local government expenditures on water pollution abatement: (1) demand variables, (2) supply of funds variables, (3) technical constraints, and (4) a set of proxies for public sector distribution. While these variables seem to be relevant to any decision model, the form in which some of these terms enter the regression are model specific.

Six separate variables are used to measure intermunicipality variance in the demand for sewage treatment facilities: median family income (+), urbanization (+), education (+), population density (-), proximity to the polluted river (+), and a proximity to the river, property ownership interaction variable (+). All six variables can be expected to affect citizens' utility functions and therefore their votes. The first four are standard terms, whose use can be justified on the grounds reviewed previously. In addition, proximity of an area to the river affects the potential recreational and aesthetic benefits to be culled from any clean up. A riverside town should therefore, *ceteris paribus*, spend more on pollution abatement. The proximity-property interaction term is discussed at length below.

Although the model developed here posits some discretion by local decision makers on the level of government expenditures on sewage treatment facilities, technical parameters are nevertheless important. Two towns with equal commitments to clean water may well have different expenditure levels as a result of differences in the initial pollution problem. In short, we require a proxy for inter-town variations with cost of cleanup. Average per capita waste flow (both household and industrial) is used here to pick up this factor.

The supply of funds available, or the fiscal strength of a town, represents an additional expected input into the level-of-expenditure decision. Two proxies seem to be suitable for use here: the percentage of sewage treatment costs that towns anticipate that the federal and state governments will contribute, and the current year's effective tax rate divided by median family income of the town. This latter variable unfortunately captures two opposing effects. First, the current tax rate reflects a town's ability to pay for new projects. On the other hand, a high current tax rate may also reflect the relatively high willingness to pay for public projects of the town. Given the presence in the equation of other strong demand, or willingness to pay, variables, the extent to which the tax rate term will pick up this latter effect will be minimized.

Finally, the baseline distribution of public services and taxes is an important determinant of the level of new expenditures chosen by the government for water pollution abatement. The differences between interest group and purely democratic voting models are captured in the treatment of this subset of terms.

In both the private sector and the public sector, we suppose that ultimately people choose goods on the basis of a comparison of the price of goods and the value to them of those goods. However, unlike the private sector, the prices of public goods are not well known. When citizens vote to spend a given amount of a new sewage treatment facility, they face some probability distribution of "costs" to themselves. What they ultimately pay depends upon which alternative financing scheme is used by the municipality. For a childless and socially unconscious voter, educational expenditures have no value. However, as a property owner he is hurt by increases in the property tax. Clearly if the sewage treatment plant under consideration has some utility for him, his vote on the issue of total municipal funds to be allocated to the project will depend upon whether he anticipates funding through cutbacks on education or through tax increases.

In fact, local municipalities have two basic options in financing new projects: increasing government revenue or cutting back other expenditures (substitution). There are, in turn, six revenue sources available to local governments: the property tax, the corporation and income tax, licenses and permits, fines and forfeits, grants and gifts, and commercial revenue. Of these the corporation and income tax, and grants and gifts are effectively beyond the control of the local decision makers. On the other hand, licenses and permits, and fines and forfeits, while manipulable generally each comprise less than 1% of the typical local budget. Commercial revenue is controllable and relatively large. However, in general, it is used by government strictly to cover direct costs of the local service offered. It does not serve as a more general revenue raising venture. On the revenue side, then, the typical municipality can raise new revenue only by increasing the property tax rate.

Consider first the one man/one vote model. If the benefits of the new program do not tend to go to those who would suffer the losses of expenditure cutbacks, support for a new program will be lower. However, if the cutback services are only enjoyed by a few--support for the new project will be higher. All of those people who do not risk having to give up the benefits of alternative expenditures, will clearly vote for the project. People, in sum, will consume more of a public good if they themselves do not have to pay for it.

Given the importance of the property tax in the local budget, it is reasonable to use the ratio of property owners to total population as a proxy for the distribution of taxes. In doing so we are assuming that property owners react more strongly to tax increases than renters--even if the latter wind up "bearing" the tax via rent level changes in the long run.[10]

The role of the property tax in the decision process is particularly interesting. In the present analysis, it appears twice. This illustrates the dual effect of a pollution abatement facility on property owners. First, owning property increases the anticipated price of the new project to the voter. However, the new sewage treatment project also influences property values. The extent of this effect depending on the proximity of the property to the to-be-cleaned-up river. An interaction variable of property tax payments and closeness to the river is introduced to capture this effect.

This relationship between benefits and costs helps to determine the effect of the property distribution on the level of sewage expenditures in a town. Consider a typical property owner: he may have children and thus care about the level of local educational expenditures, and so on. However, these effects are not systematically related to property ownership. In general, the other economic and demographic terms should pick up the property owner's non-property related preferences, while his property-related ones are reflected in these other variables. As a property owner his vote will depend upon the expected increase in the market value of his property resulting from the new sewage treatment plant construction weighed against the expected property tax increase.

In a one man/one vote model, the politician chooses a level of expenditures by comparing the number of people for whom Benefits is greater than expected costs against the number for whom Benefits is less than expected costs. In an interest group model, on the other hand, the politician is concerned with not only the number of winners and losers, but also with how much members of various groups are effected.

In general, the amount of property owned will not change how and individual votes, and therefore it is irrelevant to the expenditure decision of the politician in the pure democracy model.[11] In this case, only the fact of property ownership and not the quantity of property owned is relevant. On the other hand, the intensity of a voter's preferences on expenditure levels will depend on the market value of the property he owns. Hence, such values are critical to and interest group formulation of the voting process. Thus, one way to operationally differentiate between the interest group and purely democratic models is to include the market value of property in a regression based on the former and exclude it from the latter. The extent to which the market value term is significant should give us some idea as to the explanatory power of each of the two formulations.

The role of industrial property also differs depending upon whether interest groups or pure democracy is the voting rule. In an analysis predicated on the interest group model, the market value of industrial property is critical; industry forms a basic interest group and the effect of municipal budgetary policy on profits is one of the foundations of its vote. Industrial property can be treated somewhat differently than the residential property discussed above. Given that much industrial land is unattractive for residential purposes, its value is not likely to be changed much by cleaner water, Hence, for industry there are not such clear benefits associated with new sewage treatment facilities. On the other hand, since industry does pay property taxes, the loss from such new expenditures is likely to be considerable. Thus in an interest group model, to the extent that industries form a viable, active group, the value of industrial property in an area is likely to decrease the expenditures made on water pollution control in an area.

On the other hand, the value of industrial property is irrelevant to the level of expenditures selected under rules of pure democracy. If the controllers of the industrial property are not residents of the area, they have no vote; if they are voters, then following the analysis of residential peoperty, only the fact of their ownership and not the magnitude of the property owned counts.

The economic and demographic variables identified thus far are relevant to both the adding machine and the organic state theories. In the adding machine model, these variables constitute the core of expenditure determination. In the alternative model, these variables act as a constraint on the growth maximizing behavior of the political actor. One way then to differentiate between the two models is to find a proxy to measure the effectiveness of the voting constraint in the latter. In economic theory, the extent to which the firm is constrained to maximize profits is captured by the economic market power of that firm. By analogy, the importance of the voting constraint on government behavior in the organismic political model can be summarized by a political "market power" term.

The first use of some notion of political competition in budget analysis was made by John Fenton.[12] Fenton, in a study of interstate budgetary variation, suggested that two-party competition increased the attention paid by the government to the poor. Fenton's indices were later adopted by Fisher in his more general expenditure determination model.[13] In Fisher's regression, the level of political competition decreses the level of expenditures in an area. This result is consistent with the growth maximizing analysis above, although Fisher himself leaves the underlying decision model of government in his work unspecified.

To the extent that politicians try to expand the public sector and not maximize votes, we would expect the level of political competition to be inversely related to the level of new expenditures made. If , on the other hand, the true voting model is Buchanan's adding machine state, then the political competition level should be insignificant.

III.3. Empirical Analysis

In this section, we will test four models of the determination of the level of expenditures made by local governments on water pollution control: adding machine-pure democracy, adding machine-interest groups, organic state-pure democracy, organic state-interest groups. The distinction between interest group and pure democracy will be made by the inclusion in the former regression of variables for the magnitude of residential and industrial property in an area; the organic and adding machine states will be differentiated by the inclusion of a political competition variable in the regression based on the former model.

III.3.1 The Data Base

Water pollution control facilities are financed by federal, state and local governments. The first task then is to allocate costs among these three levels of government. Two pieces of federal legislation were relevant for this work. The Federal Water Pollution Control Act of 1956, as amended, formed the basis of the allocation of historical costs. The Federal Water Pollution Control Law of 1972 was used to predict patterns of allocation for future projects.

Under Section 8 of the amended 1956 statute, the Federal government agreed to pay between 30% and 50% of the total construction costs of sewage treatment plants; the federal share guaranteed under this act varied according to the state's willingness to contribute to the project.[14] Under Section 202 of the new Bill, the federal share is somewhat larger: up to 75% of construction costs are now paid for by the federal government. A need formula is used to determine the precise share.

State contributions to costs of construction also vary: New Hampshire, for example, contributed 20% of the financing charges of bonds floated by municipalities to finance construciton of facilities. Massachusetts provides no comparable aid in absorbing finance charges, but is somewhat more generous than New Hampshire in providing initial funds.

All operating and maintenance costs of sewage treatment plants are borne by local municipalities.

The total capital costs of construction of new treatment plants budgeted by our towns in the present period is given in Table III.4. For most of the towns in the study area, no previous expenditures on treatment plants were made. For those towns which did have previous expenditures, we added the present value of those former expenditures to the current allocated costs.

III.3.2 Econometric Evidence

In this section, we test four models of the determination of the level of expenditures made by local governments on water pollution abatement. The dependent variable in our regressions is the per capita costs rather than an annual amortization figures because we believe that these capital costs constitute the initial decision variable, whereas amortization costs simply represent the budgetary *result* of

Table III.4

Capital Costs of Sewage Treatment Plant Construction

The Merrimack Basin

Town	Level of Expenditures
Lawrence	$4768000
Andover	640000
North Andover	624000
Methuen	1963000
Haverhill	2880000
Groveland	320000
Fitchburg	6440000
Westminster	212000
Lunenberg	1274000
Lowell	2818000
Dracut	552500
Tewksbury	681500
Chelmsford	948000
Billerica	278200
Leominster	2248000
Nashua	2100480
Merrimack	242333
Concord	1537961
BOW	127039
Hudson	144000
Pemboke	109000
Hooksett	388888
Franklin	329990
Tilton	116730
Northfield	99180
Belmont	112756
Laconia	673724
Gilford	145707
Meredith	131468
Sanbornton	46195
Manchester	1535040
Bedford	104220
Goffstown	275942
Hillsborough	375000
Hopkinton	380000
Plymouth	75000
Warner	230000
Alton	625000
Henniker	370000

that decision. The use of a per capita term reflects our concern with costs to individuals (rather than towns) of local government programs.

The models tested are given below:

1. Adding Machine-Pure Democracy

$$X = B_0 + B_1Y + B_2E + B_3D + B_4N + B_5V + B_6S + B_7G + B_8T + B_9C$$

2. Adding Machine-Interest Groups

$$X = B_0 + B_1Y + B_2E + B_3D + B_4N + B_5V + B_6S + B_7G + B_8T + B_9C + B_{10}J + B_{11}MIS$$

3. Organic-Pure Democracy

$$S = B_0 + B_1Y + B_2E + B_3D + B_4N + B_5V + B_6S + B_7G + B_8T + B_9C + B_{10}POL$$

4. Organic-Interest Groups

$$X = B_0 + B_1Y + B_2E + B_3D + B_4N + B_5V + B_6S + B_7G + B_8T + B_9C + B_{10}J + B_{11}NIS + B_{12}POL$$

where:

X = per capita level of expenditures on sewage treatment

Y = median income

E = median number of years of school completed

D = population density in the town

N = river miles + total town area

V = N + property distribution

S = per capita waste dischard (municipal + industrial)

G = percentage of total costs provided by federal and state government

T = previous year's tax rate divided by median income

C = number of homeowners/population

MIS = percentage of accessed tax base in residential property

J = median value of home divided by median fmaily income

POL = actual turnover of town administration, divided by possible turnover

For the most part, the variables defined above follow directly from the previous analysis. However, C, J, MIS and POL require some additional discussion.

We suggested above that property ownership was an important factor in shaping voter preferences about optimal government expenditure levels. We also indicated that there were two dimensions of property ownership which should be considered. First, for a one man/one vote case, only the fact of ownership and not the more elusive magnitude of property owned is relevant to the vote.

To reflect this, we use variable C. There are three groups of property holders in a typical town: home owners, landlords and business property holders. There is no data available which can tell us the number of landlords and business--property holders relative to the total population of a town. However, we do have data on the relative number of home owners. We assume that landlords and businessmen are either (1) not voting residents in a town, and thus excluded from the base population; or (2) voting residents who also own their own homes, and thus included already in the home-ownership data. In that case, we can use home ownership data by itself to reflect property ownership in a town. Following this reasoning, we have set C equal to the number of home owners in a town divided by the total population in that town. As C increases, the more important we would expect property-related factors to become in establishing the town budget.

The variables J and MIS are both designed to capture the intensity of preferences of property owners, and thus are included only in the interest group regressions. The usual approach is to use the percentage of residential property in a town to reflect interest group concerns. This assumes that as the percentage of residential property in a town decreases, the proportion of any property tax increase generated by shifts in government expenditures which will be absorbed by voting residents also decreases. Thus, the lower the percentage of residential property in an area, the smaller will be the costs of government expansion to voters. Residential property in this formulation consists of both home owned property and rented property.

In contrast, in this study, we exclude renters from the property interest group. MIS is equal instead to the percentage of the total value in a town which consists of owned homes. Participating in an interest group involves certain costs: in particular, there is the cost of information (viz. what group do I belong to?) and the costs of participation. Only if the expected loss from an adverse vote is greater than the sum of these two costs, will voters form a viable interest group. We would argue that (1) cost of information is higher to the renter than to the owner, given the more indirect nature of the effect of a tax increase on rents, and (2) expected losses from tax increases are smaller to the renter than to the owner. The latter effect is attributable to the fact that it is only in the long run that renters pay the tax increase. The long run here being the time it takes the stock of rental housing to reach the new equilbirium level. This may be quite long indeed. Thus we have decided to exclude renters from the MIS variable on the grounds that their expected interest group participation is considerably lower than that of home owners.

J, the second interest group variable, is equal to the median home value in a town divided by the median income of families in that town. This term is designed to reflect the importance of property values in the total wealth of individuals. Thus, the higher are MIS and J, the more intense we would expect the preferences of property owners to be.

The organic and adding machine models of the state are distinguished by the inclusion in the former model of some variable reflecting the level of political rivalry in a town. Political competition in an area is a very complex notion, and the proxy used in this study is a rough one at best. In this study, political competition was measured by the ratio of actual turnover in elected officials of a town to the possible turnover. Thus, if a town mayor serves a two year term, the maximum mayoral turnover in that town for a decade is equal to five. The POL term in our regressions thus varies from zero to one, with higher values signifying more competition. Admittedly, this variable does not differentiate between towns in which an incumbent wins an election unopposed and one in which he wins only after a hard battle with some political challenger, even though the implicit competition in the two cases is quite different.

Using econometric evidence to differentiate among the four models posed in Section 2 is a very difficult task. The models are all quite complex, and the sample size in this study is not large. Thus, I believe the real test of the validity of each of the models is to be found in their internal consistency, and the extent to which they are consistent with out experience in the real world. Nevertheless, some information is provided by the regression results presented below.

We first estimated our four equations by the unweighted ordinary least squares method(see Table III.5). An examination of a plot of the residuals from equations 1 through 4 suggested that our error terms were heteroskedastic. That is, the variance in our errors was proportional to the population of the towns under study. In order to correct for this, we used the standard approach of weighted regression, weighing the observations by the square root of population. The results of this weighted ordinary least squares procedure are given in equations la through 4a in Table III.6 below.

The fairly low R^2 terms are to be expected. Federal legislation and indivisibilities in the production of sewage treatment limit the

Table III. 5

Regressions Explaining Inter-town variations in Per Capita Capital Expenditures on Sewage Treatment -- O.L.S.

Equation	Y	E	D	N	V	S	G	T	C	J	MIS	POL	R^2
1	-.000754	-14.4	-.0275	116	87.9	-5809	.177	-528	234				.222
	(.0102)	(33.9)	(.0142)	(123)	(73.6)	(.00000508)	(.719)	(2006)	(140)				
2	.00131	-20.4	-.0295	116	95.6	-3935	.226	1011	262	21.7	-.153		.194
	(.0108)	(36.6)	(.0157)	(126)	(77.05)	(.00000523)	(.749)	(2213)	(150)	(37.4)	(.389)		
3	.00201	-11.06	-.0243	115	82.03	-2984	.168	-409	239			-26.5	.208
	(.0106)	(34.9)	(.0156)	(124)	(75.2)	(.00000516)	(.726)	(2037)	(142)			(51.2)	
4	.0000615	-16.7	-.0263	115	89.2	-1246	.207	-846	263	18.9	-.162	-22.6	.176
	(.0113)	(38.02)	(.0175)	(127)	(79.3)	(.00000532)	(.758)	(2270)	(151)	(38.4)	(.394)	(53.02)	

Table III. 6

Regressions Explaining Inter-town variations in Per Capita
Capital Expenditures on Sewage Treatment -- Weighted Regressions

Equation	Y	E	D	N	V	S	G	T	C	J	MIS	POL	R^2
1a	-.00256	-3.43	-.0215	55.9	99.0	39184	.244	-149	221				.220
	(.00919)	(28.0)	(.0105)	(106)	(56.8)	(.00000512)	(.545)	(1656)	(131)				
2a	-.000422	-3.57	-.0196	45.1	103	42593	.144	-493	283	20.51	-.495		.235
	(.00920)	(28.3)	(.0108)	(107)	(56.4)	(.00000507)	(.550)	(1726)	(141)	(37.2)	(.334)		
3a	-.00602	3.98	-.0166	57.9	92.9	41926	.244	-190	235			-47.0	.225
	(.00968)	(28.7)	(.0113)	(106)	(56.9)	(.00000511)	(.543)	(1651)	(131)			(42.1)	
4a	-.00335	2.46	-.0159	47.1	97.8	44447	.150	-486	288	18.02	-.460	-37.3	.231
	(.00981)	(29.2)	(.0117)	(108)	(56.9)	(.00000509)	(.551)	(1731)	(142)	(37.4)	(.337)	(42.5)	

ability of local governments to adjust expenditures to intermunicipality differences in preferences. Given the caveats on the small sample size and the difficulty in measuring some of our variables, we can nevertheless extract some information from the regressions.

First of all, the inclusion of interest group variables in the regression does improve its predictive ability. The corrected R^2 increases,when we included these variables in the regression. Political competition similarly improves the R^2 somewhat.

Consider now the effect of each of the individual terms on the level of per capita expenditures on water pollution abatement in an area.

Population density is negative and fairly significant in all four of the equaitons. This result is consistent with the hypothesis that economies to scale exist in the provision of certain public goods.

We have two measures of benefits of water pollution abatement in our regressions, N and V. N, the river miles in a town divided by the total area in that town, is intended to reflect the <u>gross</u> aesthetic, recreational and land value benefits potentially available to town residents from water pollution abatement. In the regressions, N is positive (the right sign) but insignificant. V is equal to N divided by our property ownership variable and is intended to reflect the <u>net</u> benefits associated with pollution abatement. When river miles relative to town acreage is high and property ownership low, voters stand to benefit (recreationally and aesthetically) without paying very much. Conversely, when N is low and property ownership high, voters tend to pay a great deal without reaping very high rewards (aesthetically, recreationally or in land value increases). In the regressions V is both of the right sign (positive) and significant at the 10% level. This is a very interesting result. It suggests that voters consider both the costs and benefits associated with water pollution abatement in making choices. Moreover, their preferences, to some extent, do seem to be registered in public decisions.

The property tax distribution variable C is similarly positive and significant. This result is at variance with much of the other work done 'on the detrminants of general expenditure levels in a town, which has found that the higher the proportion of a town's population which owns property the lower expenditures will be. This sign difference is a function of the interdependence of the benefits and costs associated with water pollution abatement alluded to above. In the previous econometric work in this field, the dependent variable is defined so that while the costs of expenditures to voters are a direct function of property ownership, benefits did not depend on such ownership. This is not true in the case of water pollution abatement expenditures. Here both the benefits and costs vary with property ownership.

Thus, the positive sign for C is not surprising, and suggests that voters at least believe that benefits from sewage treatment facilities will outweigh any coincident property tax increases.

Furthermore, given the other work reported on in Section II, this variable may be reflected in part in differences in tastes and attitudes among towns.

While the political competition variable in the regressions is not highly significant, it is of the right sign (negative). Given the crudeness of the variable, this is about all we could expect. The results do suggest that in towns where political competition is fierce, there is some tendency for sewage treatment expenditures to be lowered.

Perhaps the most interesting result of our regressions from the point of view of the incidence of pollution abatement costs is that the coefficient of Y, income, is not significantly different from zero. Part of this is the result of the collinearity between income and the other variables in the equation. As regression 5 shows (see Table III.7), slightly over 81% of the variance in income between towns can be explained by the other terms in the regressions. Nevertheless, this work does suggest that income, given the other variables, is not highly associated with intermunicipality variance in water pollution abatement expenditures.

Four basic conclusions arise from this analysis of per capita pollution abatement expenditures:

1. In general, voters appear to respond to their perceptions of net rather than gross benefits of pollution abatement.

2. Towns are not absolutely constrained to some level of expenditures on sewage treatment facilities, and can respond in some way to intermunicipality variance in the demand for programs.

Table III.7

Income as a Function of the Other
Variables in the Expenditure Equation

$$
\begin{aligned}
y = & \underset{(6510)}{-29240} + \underset{(543.2)}{3166E} + \underset{(.1661)}{.097D} + \underset{(2198)}{852N} \\
& - \underset{(1482)}{1079V} + \underset{(676600)}{848250S} - \underset{(13.58)}{14.5G} \\
& - \underset{(69800)}{281950T} + \underset{(2007)}{2858C} - \underset{(479.0)}{639.8J} + \underset{(5.426)}{12.68MIS}
\end{aligned}
$$

Corrected R^2 = .81

3. Both interest group pressure and political competition in an area help to explain per capita expenditure levels. The test is, of course, not a definitive test among the alternative models posed above. However, it does suggest that we should consider alternative theories of the state more seriously.

4. Finally, the median income level in a town is not closely associated to the waste treatment expenditures of that town.

III.3.3 Distribution of Government Costs of Water Pollution Abatement among Income Classes

In order to determine the incidence of water pollution control expenditures among income classes, we must estimate not only the absolute level of those expenditures but also the way in which expenditures are to be financed.

As discussed earlier, local governments can increase the property tax or they can reduce other expenditures. If the total expenditure is to be financed via a property tax increase, then net incidence can be found by comparing the distribution of property taxes among income classes with the distribution of water pollution abatement benefits. If, on the other hand, the new expenditure is made at the expense of some old expenditure, then incidence depends on the distribution of benefits from the now foregone expenditure.

Strictly speaking, it is inappropriate to simply look at what happens to town budgets once we introduce the new pollution abatement expenditures. Instead, we should compare the after-the-pollution-expenditure budget with what we believe the budget would have been without the pollution expenditures. In more technical terms, our primary concern should be with differential rather than specific incidence.[14]

In the absence of a reliable crystal ball, we are forced to estimate differential incidence by making a set of assumptions about what public goods would have been provided without the pollution expenditure. We can then compare this estimated public budget with the actual budget to determine the source of pollution abatement funds. The conclusions which result thus clearly depend heavily on the choice of assumptions. Hence, here we make two distinct assumptions in order to illuminate the range of possibilities.

In most of the towns in New England, school expenditures are decided separately from other town expenditures, and presented to the town officials as a given. In this study, then, we will not treat educational expenditures as a possible source of new pollution abatement funds. Instead, we will assume they are exogenous to the budgeting decision.

To provide the estimates we require, it is necessary to forecast what would have happened to town expenditures without the pollution control program. To do this we will use simple projection techniques. If actual spending for non-school, non-pollution control items is above this forecast, then we will assume that expenditures are not being curtailed but instead that pollution control is being property-tax financed. If actual spending is less than the forecast, we will conclude that spending cuts have been made.

This process gives us an estimate of the extent to which a town relies on taxes or expenditure substitutions to finance sewage treatment; we can then use these estimates in conjunction with the previous work on tax and expenditure incidence to allocate pollution abatement costs among income classes.

In developing this incidence analysis work, we used data from two large towns in the Basin area: Nashua, New Hampshire and Leominster, Massachusetts. Both towns financed new water pollution treatment facilities in the 1960's, and thus we have budget data available for both the pre and post pollution expenditure periods.

In Table III.8 we present the actual and expected growth paths of the two towns under consideration, and use the differences in these two paths to allocate pollution expenditure between the two financing modes. The expected growth paths were derived under two alternative assumptions. Assumption 1, the conservative path, posits a yearly growth in the relevant category equal to the average annual growth rate in the years prior to the pollution expenditure (1960 for Nashua, 1964 for Leominster). This gives us a growth rate of 6.25% in Nashua and 6.4% in Leominster. Assumption 2, the liberal path, posits a growth rate equal to the weighted average of the growth rates in the years prior to the pollution expenditure, where the weights are highest in the most recent years. This assumption yields a growth rate of 5.8% in Leominster and 9.93% in Nashua. These estimates suggest that at least some part of the new expenditures are made at the expense of other public goods.

Table III.8 Local Government Financing Projections:
Leominster

Pre-sewage Plant

	1957	1958	1959	1960	1961	1962	1963
General revenue	3414	3508	3635	4507	4976	5126	5718
Property Tax		2097	2189	2286	2392	2507	2647
Education Expenditures	1221	1284	1344	1435	1509	1569	1800
Treatment Facilities							
GR - Ed	2193	2225	2291	3071	3467	3557	3918
Percentage Increase		1.46	3.00	34.00	12.89	2.60	10.15

Leominster

Post-sewage Plant

	1964	1965	1966	1967	1968	1969	1970
General Revenue	6068	7313	7702	8472	8924	8806	10547
Property Tax	2954	3818	3785	4125	4479	5131	6236
Education Expenditures	1842	2437	2637	3008	3437	3919	4676
Treatment Facilities	77.8	99.7	103.4	131.5	159.3	162.0	162.8
GR - Ed	4225	4876	5064	5465	5487	4886	5871
[illegible]							
Conservative Growth Path	4169	4436	4720	5023	5345	5687	6052
Liberal Growth Path	4147	4391	4649	4922	5211	5516	5840
Actual minus Expected (Conservative)	56	440	344	442	142	-801	-181
(Liberal)	78	485	415	543	276	-630	31
% Allocated to Property Tax (Conservative)	72	100	100	100	89	0	0
(Liberal)	100	100	100	100	100	0	19

Nashua

Pre-sewage Plant

	1953	1954	1955	1956	1957	1958	1959	1960
General Revenue	3099	3123	3171	3291	3477	3826	4101	4861
Property Tax	2523	2580	2579	2770	2993	3235	3457	4027
Education Expenditure	1110	1145	1081	1307	1376	1529	1632	1870
Treatment Facilities								
GR-- Ed	1989	1978	2090	1984	2102	2297	2469	2991
Percentage Increase		-.56	+5.6	-5.1	+5.9	+9.3	+7.5	+21.14

Nashua

Post-sewage Plant

	1961	1962	1963	1964	1965	1966	1967	1968	1969
General Revenue	5175	6171	6495	7240	7467	7864	8130	11030	11862
Property Tax	4140	4837	4938	5447	5883	6463	7310	8767	10112
Education Expenditure	2067	2263	2600	2856	3255	3622	3879	4805	5126
Treatment Facilities	100.8	102.2	254.37	256.04	257.7	260.3	261.1	262.7	264.4
GR - Ed	3108	3908	3895	4384	4212	4242	4251	6225	6736
Conservative Growth Path	3178	3376	3588	3812	4050	4303	4572	4858	5161
Liberal Growth Path	3288	3614	3973	4367	4801	5278	5802	6379	7012
Actual minus Expected (Conservative)	-70	+532	+307	+572	+162	-61	-321	+1367	+1575
(Liberal)	-180	+294	-78	+17	-589	-1036	-1551	-154	-276
% Allocated to Property Tax (Conservative)	0	100	100	100	63	0	0	100	100
(Liberal)	0	100	0	7	0	0	0	0	0

We can now use the estimates in Table III.8 in conjunction with the tax and expenditure work of Musgrave and others to draw some conclusions about the effects of water pollution abatement on the income distribution.

III.3.3.1 The Property Tax

The property tax is a tax on four separate kinds of goods: owner-occupied housing, rental property, commercial and industrial and farm property.

The conventional theory says that in the long run, taxes on residential property, both owner-occupied and rented, are borne by the occupant.[15] Occupants of owner occupied housing bear these taxes in the short run as well. The short-run incidence of property taxes on rental property is less clear. Traditional theory argues that since supply is inelastic in the short run , landlords must absorb the tax. On the other hand, several people have recently suggested that in oligopolistic urban rental markets property taxes may act as a signal for landlords to immediately raise rents and hence tenants bear the property tax in the short run as well.[16]

If occupants do in fact bear the burden of the residential property tax, then this portion of the tax would appear to be regressive. Housing has an income elasticity less than 1. Therefore, a property tax which is proportional to the value of property will rest relatively more heavily on low rather than on high income people.[17] This regressivity of the residential portion of the property tax is exacerbated by Federal income tax law. Homeowners can deduct from their income tax, property tax payments. The monetary value of this deduction depends on the marginal tax bracket of the homeowner. The effect of these tax laws on increasing the regressivity of residential property taxes is illustrated in Table III.9.

The incidence of the portion of the property tax which falls on commercial, industrial and farm realty is not quite as clear-cut as that on residential property. Traditional theory assumed that this part of the tax was similar to an excise tax, and therefore would be shifted completely on to the consumer.[18] It, too, was regressive since the marginal propensity to consume declined with income. This assumption has been challenged recently: the argument has been made that the tax on business property is analogous to a tax on income from capital and therefore will not be totally shifted forward unless the business involved is a monopoly.[19] In line with this reasoning, recent work has attributed one-half of the business property tax to capital and one-half to consumers.

Personal property, the last element of the property tax, is for the most part, business machines and inventories. It is assumed that this portion of the tax is shifted forward to consumers, much as any other excise tax. It, too, is regressive.

In total, the property tax seems to be somewhat regressive. Table III.10 gives the incidence of the tax as determined by four major studies: in all four, the tax is regressive throughout most of the income range.

Table III. 9

Incidence of Real Estate Taxes
Adjusted for Tax Deductions
1960

Income Class	Property Tax/ Income	Adjusted for Tax Savings
3,000 - 4,000	4.46	3.57
4,000 - 5,000	3.72	2.98
5,000 - 6,000	3.34	2.67
6,000 - 7,000	3.15	2.52
7,000 - 8,000	3.07	2.46
8,000 - 9,000	2.96	2.31
9,000 - 10,000	2.89	2.25
10,000 - 15,000	2.79	2.18
15,000 - 20,000	2.71	1.90
20,000 - 25,000	2.52	1.70
25,000 - 50,000	2.13	1.21

Source: Dick Netzer, Economics of the Property Tax, (Brookings, Washington, D.C. 1966), p. 49. Statistics compiled from U.S. Treasury Department, Statistics of Income, Individual Income Tax Returns, 1960. Only taxable returns were used.

Table III. 10

Incidence of The Property Tax

Property Tax as a Percent of Family Income

<table>
<tr><th>Income in Thousands</th><th>0</th><th colspan="2">2</th><th colspan="2">4</th><th colspan="2">6</th><th>8</th><th>10</th><th>15</th><th>20</th><th>25</th><th>30</th><th>40</th><th>50</th></tr>
<tr><td>(1) Herriott & Miller</td><td>8.3%</td><td colspan="2">5.3%</td><td colspan="2">4.3%</td><td colspan="2">3.8%</td><td>3.7%</td><td>3.8%</td><td colspan="2">3.8%</td><td colspan="4">2.5%</td></tr>
<tr><td>(2) Musgrave</td><td>6.7</td><td colspan="2">5.7</td><td colspan="2">4.7</td><td colspan="2">4.3</td><td>4.0</td><td>3.7</td><td>3.3</td><td colspan="2">3.0</td><td colspan="2">2.9</td><td>3.3</td></tr>
<tr><td>(3) Tax Foundation</td><td>6.9</td><td>5.2</td><td>4.7</td><td>4.2</td><td>4.2</td><td>3.8</td><td colspan="2">3.5</td><td>3.3</td><td colspan="6">2.4</td></tr>
<tr><td>(4) Gillespie</td><td>6.0</td><td>6.2</td><td>5.8</td><td>6.9</td><td colspan="2">5.2</td><td colspan="2">3.1</td><td colspan="7">2.3</td></tr>
</table>

(1) Herriott & Miller: "The Taxes We Pay," Conference Board Record, May 1971, and "Tax Changes Among Income Groups, 1962-68," Business Horizons, Feb. 1972.

Data from 1963 Survey of Financial Characteristics of Consumers.

Total Income = money income plus
under-reported money income
imputed income
realized capital gains
retained earnings
indirect taxes (less transfers)

(2) Musgrave: Study in progress.

Data was obtained from the Brookings Institution's Merge File compiled from the 1966 Survey of Economic Opportunity & U.S. Government Tax File.

Adjusted Family Income = factor income
+ corporate profits
+ transfers
+ imputed rent
+ wage supplements
+ insurance interest
+ other accrued capital gains

(3) Tax Foundation: Tax Burdens & Benefits of Government Expenditures by Income Class (New York, 1967).

Data compiled from: Bureau of Labor Statistics, Consumer Expenditures and Income, Survey of Consumer Expenditures 1960-61. (BLS Report No. 237-38);

U.S. Dept. of Commerce, Survey of Current Business, July 1966. and Tax Foundation estimates.

Total Income = income before taxes.

(4) Gillespie: "Effects of public expenditures on the distribution of income," in Musgrave, Essays in Fiscal Federation (Brookings, 1965)

Adjusted Income = income + benefits from government + transfers - taxes.

III.3.3.2 Expenditure Incidence

In lieu of property tax increases, local governments can choose to raise pollution abatement funds by reducing other local expenditures. We must consider then the incidence of benefits of substitutable government expenditures.

In Table III.11 we present a recent analysis by Musgrave [20] of the incidence of health and hospitals, highway, and other (non-educational) expenditures. As we can see, all three categories are progressive: the poor benefit more than proportionately from expenditures. Health care, as we might expect, is the most progressive; highways the least. Obviously there are a great many assumptions involved in making such projections and we cannot review them here. However, although our information is limited, these numbers do represent one expert "best guess" of the underlying pattern.

III.3.3.3 Overall Distribution Impact

In Table III.12 we have computed an estimate of the incidence of pollution abatement costs under the Leominster and Nashua financing scheme. The share of costs covered by property tax increases was allocated among income classes in accordance with the Musgrave tax figures. The allocation of benefits lost through the expenditure substitution process was accomplished by (1) assuming that in the absence of pollution abatement expenditures, the *relative* size of other expenditures in the budget would have remained constant; and (2) using expenditure incidence estimates to allocate costs of foregone

Table III. 11

Incidence of Local Government
Expenditures

	Benefits as a Percent of Income		
Income group	Highways	Health	other
Under 2,000	1.3%	5.9%	4.2%
2 - 4,000	2.0	6.8	4.8
4 - 6,000	2.2	3.4	4.2
6 - 8,000	2.3	1.9	4.6
8 - 10,000	2.1	1.1	4.2
10 - 15,000	1.8	.6	4.0
15 - 20,000	1.3	.5	3.4
20 - 30,000	.6	.3	3.1
30 - 50,000	.8	.2	3.7
50,000 +	.5	.0	3.6

Source. Richard Musgrave, _op_._cit_. 1973.

Table III. 12

Incidence of Pollution
Abatement Costs for

LEOMINSTER Conservative Estimate

Year / Income Group	1964	1965	1966	1967	1968	1969	1969
Under 2.000	5.9%	6.7%	6.7%	6.7%	6.4%	4.1%	4.1%
2 - 4,000	5.4	5.7	5.7	5.7	5.6	4.7	4.7
4 - 6,000	4.5	4.7	4.7	4.7	4.6	3.9	3.9
6 - 8,000	4.3	4.3	4.3	4.3	4.3	4.1	4.1
8 - 10,000	3.9	4.0	4.0	4.0	4.0	3.7	3.7
10 - 15,000	3.6	3.7	3.7	3.7	3.7	3.4	3.4
15 - 20,000	3.2	3.3	3.3	3.3	3.2	2.9	2.9
20 - 30,000	2.9	3.0	3.0	3.0	3.0	2.6	2.6
30 - 50,000	3.0	2.9	2.9	2.9	2.9	3.1	3.1
50,000 +	3.2	3.3	3.3	3.3	3.3	2.9	2.9

LEOMINSTER Liberal Estimate

Year / Income Group	1964	1965	1966	1967	1968	1969	1969
Under 2,000	6.7%	6.7%	6.7%	6.7%	6.7%	4.1%	4.6%
2 - 4,000	5.7	5.7	5.7	5.7	5.7	4.7	4.9
4 - 6,000	4.7	4.7	4.7	4.7	4.7	3.9	4.1
6 - 8,000	4.3	4.3	4.3	4.3	4.3	4.1	4.1
8 - 10,000	4.0	4.0	4.0	4.0	4.0	3.7	3.7
10 - 15,000	3.7	3.7	3.7	3.7	3.7	3.4	3.5
15 - 20,000	3.3	3.3	3.3	3.3	3.3	2.9	3.0
20 - 30,000	3.0	3.0	3.0	3.0	3.0	2.6	2.7
30 - 50,000	2.9	2.9	2.9	2.9	2.9	3.1	3.0
50,000 +	3.3	3.3	3.3	3.3	3.3	2.9	3.0

NASHUA Conservative Estimate

Year / Income Group	1961	1962	1963	1964	1965	1966	1967	1968
Under 2,000	3.4%	6.7%	6.7%	6.7%	5.4%	3.4%	6.7%	6.7%
2 - 4,000	4.1	5.7	5.7	5.7	4.1	4.1	5.7	5.7
4 - 6,000	3.6	4.7	4.7	4.7	4.3	3.6	4.7	4.7
6 - 8,000	3.9	4.3	4.3	4.3	4.1	3.9	4.3	4.3
8 - 10,000	3.6	4.0	4.0	4.0	3.8	3.6	4.0	4.0
10 - 15,000	3.3	3.7	3.7	3.7	3.6	3.3	3.7	3.7
15 - 20,000	2.8	3.3	3.3	3.3	3.1	2.8	3.3	3.3
20 - 30,000	2.4	3.0	3.0	3.0	2.8	2.4	3.0	3.0
30 - 50,000	2.8	2.9	2.9	2.9	2.9	2.8	2.9	2.9
50,000 +	2.7	3.3	3.3	3.3	3.0	2.7	3.3	3.3

NASHUA Liberal Estimate

Income Group / Year	1961	1962	1963	1964	1965	1966	1967	1968
Under 2,000	3.4%	6.7%	3.4%	3.5%	3.4%	3.4%	3.4%	3.4%
2 - 4,000	4.1	5.7	4.1	4.0	4.1	4.1	4.1	4.1
4 - 6,000	3.6	4.7	3.6	3.6	3.6	3.6	3.6	3.6
6 - 8,000	3.9	4.3	3.9	3.8	3.9	3.9	3.9	3.9
8 - 10,000	3.6	4.0	3.6	3.5	4.0	4.0	4.0	4.0
10 - 15,000	3.3	3.7	3.3	3.2	3.3	3.3	3.3	3.3
15 - 20,000	2.8	3.3	2.8	2.7	2.8	2.8	2.8	2.8
20 - 30,000	2.4	3.0	2.4	2.3	2.4	2.4	2.4	2.4
30 - 50,000	2.8	2.9	2.8	2.7	2.8	2.8	2.8	2.8
50,000 +	2.7	3.3	2.7	2.6	2.7	2.7	2.7	2.7

benefits among income classes.

Table III.12 presents the results of these calculations for Leominster and Nashua. Two things are clear from this work:

(1) In general, costs which are covered by property tax increases are more regressive than those financed by alternative expenditure reduction.

(2) The regressivity/progressivity of the expenditure substitution financing depends critically on the pre-pollution expenditure allocation of government expenditures. Thus expenditure substitution is more regressive in towns in which health and welfare expenditure is a prominent budget item, than in towns in which highways absorb a major portion of the town budget. Thus expenditure substitution is more regressive in Leominster, than it is in Nashua (where highway expenditures are large). Table III.13 summarizes the division of budgetary expenditures in the two towns.

Several interesting results emerge from this analysis:

(1) In general, analyses which attribute the total cost of water pollution expenditures to the property tax overestimate the regressivity of those expenditures, given the assumptions we have made.

(2) Given the possibility of expenditure substitution, water pollution abatement expenditures will tend to be least regressive in those towns whose budgetary patterns are most regressive, i.e., least pro-poor, in the period prior to pollution expenditures.

Table III. 13

NASHUA ANNUAL EXPENDITURES

Payments in Thousands of Dollars

	1962	1963	1964	1965	1966	1967	1968	1969
General Government	527	573	571	662	690	739	878	928
Public Safety	989	100	114	121	141	158	165	200
Health & Sanitary	649	693	729	759	850	766	737	141
Highway	109	107	115	125	119	137	172	181
Libraries	127	131	141	159	173	183	249	261
Public Welfare	97	95	104	114	116	117	100	98
Parks,Recreation	136	119	140	177	169	248	227	227
Public Service	195	223	243	289	288	292	324	77
Interest	175	253	287	308	340	360	397	619
Unclassified	667	836	816	880	321	427	777	600
Education	226	260	285	325	362	387	480	512

NASHUA ANNUAL EXPENDITURES

Percentage

	1962	1963	1964	1965	1966	1967	1968	1969
General Government	8.4	8.2	7.5	7.8	8.2	7.9	7.8	7.8
Public Safety	15.6	14.4	15.2	14.4	16.8	17.0	14.7	16.8
Health & Sanitary	1.0	.9	.9	.9	.0	.8	.6	1.2
Highway	17.3	15.3	15.3	14.9	14.2	14.8	15.3	15.2
Libraries	2.0	1.8	1.8	1.9	2.0	1.9	2.2	2.2
Public Welfare	1.5	1.3	1.3	1.3	1.3	1.2	.9	.8
Parks, Recreation	2.1	1.7	1.8	2.1	2.0	2.6	2.0	1.9
Public Service	3.0	3.2	3.2	3.4	3.4	3.1	2.9	.6
Interest	2.7	3.6	3.8	3.6	4.0	3.8	3.5	5.2
Unclassified	10.5	11.9	10.8	10.4	3.8	4.5	6.9	5.0
Education	35.6	37.2	37.8	38.7	43.0	41.8	42.8	43.0

LEOMINSTER ANNUAL EXPENDITURES

Percentage

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
General Government	.037	.038	.034	.033	.038	.031	.033	.033	.036	.038	.037	.034
Public Safety	.135	.144	.137	.137	.142	.136	.132	.120	.130	.140	.139	.144
Health & Sanitary	.056	.054	.060	.061	.045	.038	.034	.032	.036	.030	.029	.041
Highway	.082	.085	.080	.064	.064	.058	.061	.057	.059	.064	.063	.053
Public Welfare	.155	.156	.149	.141	.139	.124	.118	.140	.039	.0007		
Veterans' services	.022	.024	.020	.021	.021	.020	.025	.025	.025	.031	.032	.030
Schools	.344	.345	.340	.367	.344	.411	.417	.425	.455	.521	.534	.527
Libraries	.013	.013	.014	.013	.014	.012	.014	.015	.014	.017	.016	.016
Recreation	.011	.012	.012	.011	.011	.007	.006	.008	.008	.013	.014	.011
Pensions	.034	.036	.034	.041	.071	.033	.035	.034	.032	.031	.032	.034
Unclassified	.034	.021	.023	.017	.015	.019	.016	.020	.021	.019	.020	.020
Public Service	.039	.039	.041	.038	.044	.046	.043	.031	.033	.034	.031	.031
Cemeteries	.011	.009	.009	.007	.007	.006	.006	.006	.005	.006	.006	.005
Admin. of Trust Funds	.001	.001	.0009	.001	.0008							
Interest	.019	.018	.042	.043	.040	.052	.053	.048	.046	.051	.044	.050

LEOMINSTER ANNUAL EXPENDITURES

Payments in Thousands of Dollars

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
General Government	158	169	158	163	207	186	211	238	277	287	323	342
Public Safety	564	631	635	674	764	806	837	853	980	1052	1217	1447
Health & Sanitary	233	237	278	302	242	230	216	229	277	229	257	414
Highway	343	371	371	316	344	346	390	406	448	487	553	537
Public Welfare	647	680	688	690	745	737	746	989	707	59		
Veterans' Services	91	106	96	107	117	120	159	179	190	235	281	302
Schools	1435	1509	1569	1800	1842	2436	2637	3008	3437	3919	4676	5290
Libraries	54	59	64	67	75	74	89	111	111	130	146	161
Recreation	48	54	57	57	58	42	42	57	64	99	125	117
Pensions	145	159	159	203	382	200	224	247	248	238	280	340
Unclassified	145	93	108	85	82	113	105	148	165	148	182	201
Public Service	165	172	191	186	238	277	275	221	252	256	277	311
Cemeteries	48	42	41	36	39	38	43	46	44	46	51	55
Admin. of Trust Funds	4	5	4	7	4							
Interest	83	82	193	211	216	311	338	346	353	384	389	509
Total	4170	4376	4621	4911	5363	5922	6320	7084	7561	7521	8763	10,033

FOOTNOTES

1. James Buchanan, "The Pure Theory of Government Finance: A Suggested Approach," Journal of Political Economy, December 1949. Buchanan and Tullock, The Calculus of Consent (University of Michigan Press, Ann Arbor) 1962. Anthony Downs, An Economic Theory of Democracy (Harper's, New York) 1957.

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3. Kenneth Arrow, Social Choice and Individual Values, (Yale Press, New Haven), 1970. Abram Bergson, "A Reformulation of Certain Aspects of Welfare Economics," Quarterly Journal of Economics, February 1938, pp. 314-344. Paul Samuelson, "The Pure Theory of Public Expenditures," Review of Economics and Statistics, November 1954.

4. Duncan Black, The Theory of Committees, (Cambridge University Press, Cambridge, England), 1968. Otto Davis and Melvin Hinich, "A Mathematical Model of Policy Formation in a Democratic Society," in Joseph Bernd, Mathematical Applications in Political Science, Vol. 2 (Arnold Foundation Press, Dallas), 1966.

5. Robert Dorfman and Henry Jacoby, "A Model of Public Decisions Illustrated by a Water Pollution Policy Problem," HIER discussion paper #91 (Cambridge, MA) October 1969.

6. O. E. Williamson, The Economics of Discretionary Behavior: Managerial Objectives in a Theory of the Firm (Markham, Chicago), 1967. William J. Baumol, Business Behavior and Growth (Harcourt, Brace and World) 1967. Robin Morris, The Economic Theory of 'Managerial' Capitalism (free Press of Glencoe), 1964.

7. William Niskanen, Bureaucracy and Representative Government, (Atherton, New York), 1971.

8. Solomon Fabricant, The Trend in Government Activity in the U.S. since 1900, (National Bureau of Economic Research, New York). 1952, esp. chapter 6, pp. 113-139.

9. Glenn W. Fisher, "Interstate Variation in State and Local Government Expenditures," National Tax Journal, March 1964, pp. 57-74. Ira Sharkansky, "Some More Thoughts about the Determinants of Governement Expenditures," National Tax Journal, June 1967, pp. 171-9. Richard Spangler, "Effect of Population Growth upon State and Local Government Expenditures," National Tax Journal, June 1963, pp. 193-6. Seymour Sacks and Robert

Harris, "The Determinants of State and Local Government Expenditures and Intergovernmental Flows of Funds," National Tax Journal, March 1964, pp. 75-85. Ernest Kurnow "Determinants of State and Local Expenditures Reexamined," National Tax Journal, September 1963, pp. 252-5.

10. This is a usual assumption in neoclassical economics, c.f. Dick Netzer, The Economics of the Property Tax, (Brookings 1966). It has more recently been challenged by Helen Ladd, "The Role of the Property Tax," unpublished paper, Harvard, 1973, and Marc Roberts, "Incidence of the Property Tax," unpublished paper, Harvard, 1973.

11. Obviously the particular form of the functions involved determine whether or not this is so in any particular case. A number of formal models have been developed and analysed in this connection and do generally confirm the contention in the text.

12. John Fenton, op. cit.

13. Glenn Fisher, "Interstate Variation in State and Local Government Expenditures," National Tax Journal, March 1964, pp.57-74.

14. For a more detailed treatment of the differences between the differential and specific analysis see Richard Musgrave, The Theory of Public Finance, chapter 10.

15. c.f. Netzer, op. cit.

16. Helen Ladd, op. cit.

17. It should be noted that some recent work disputes this finding. If we use Friedman's permanent income rather than the usual money income, housing has an income elasticity somewhat larger than one. See "The Demand for Non-Firm Housing," in Harberger, The Demand for Durible Goods, (Chicago 1960).

18. c.f. Musgrave, "Distribution of Tax Payments by Income Group," National Tax Journal, March 1951.

19. Helen Ladd, op. cit.

IV. The Response of Firms to Water Pollution Sewer Charges

The purpose of this study is to examine the effects of effluent charges on the discharge of industrial liquid wastes. However important it may be, it is extremely difficult to predict the response of industrial waste discharges to an effluent charge because, for the most part, no such charge exists at present. Economists--and, for that matter, policy makers--are usually not deterred by such an obstacle. There are at least two ways to overcome it. One approach is to construct a model which simulates the production behavior of firms and to derive from this model an estimate of their response to a hypothetical effluent charge. The other approach, adopted in this study, is to search for a situation analogous to that of an effluent charge system and to analyze the response of firms in this situation. Here we use evidence available from a number of American and Canadian cities where firms which use the municipal sewer system are charged for that use partly on the basis of sewage strength, in addition to volume. Subject to these limitations in our data (which are discussed in more detail below), we have found some evidence of a significant responsiveness of waste dischargers to these charges on waste strength. In the next sections we describe our data and the econometric analyses which we have performed.

Professional econonetricians often lavish attention on sophisticated statistical techniques and esoteric methods of estimation. It is very unusual, however, to find a proportionate amount of attention devoted to the inherent meaning of the data and the real-world causal relationship which it is supposed to represent. In this study, because of the nature of the data, we found that we were forced to devote considerable attention to basic conceptual issues, such as defining what constitutes a response to a sewage charge, as well as to issues of statistical technique. Despite our efforts, we can still not be entirely certain that we are correctly interpreting the data until we can discuss our results with officials in the cities included and obtain some feedback from them.

IV.1. The Use of Surcharges on Sewage Strength

Charges for municipal sewage services are generally of fairly recent origin. According to the International City Management Association (ICMA), in 1945 less than 20% of the larger cities in the U.S., which operated a sewage collection and treatment system, levied a sewer service charge; by 1970, according to an ICMA survey, 86% of cities of all sizes with a public sewer system levied service charges.[1]

In the vast majority of cases the charge was based on volume of sewage flow, either measured directly or assumed to be some proportion of metered water supply. However, in a few cases, the charge was also based on sewage strength--usually in the form of a charge per pound of BOD and/or SS discharged in excess of a certain concentration (the precise formulae are discussed below). Of 1160 cities responding to the 1969 ICMA survey, 223 cities (19%) indicated that they had some provision for a high strength surcharge of this type. A subsequent EPA survey in December 1971 identified 287 cities which charged for sewage service at least partly on the basis of sewage strength.[2]

TABLE IV.1 CITIES WHICH WILL HAVE SURCHARGES AS OF 1974

ALABAMA
Montgomery

CALIFORNIA
Alameda
Anaheim
Fresno
Hayward
Modesto
Mountain View
Sacramento
San Jose
San Francisco
Stockton

COLORADO
Denver

FLORIDA
Jacksonville
Pensacola
Tampa

GEORGIA
Atlanta

ILLINOIS
Decatur
Peoria
Quincey

INDIANA
Layfayette

IOWA
Ames
Cedar Rapids
Des Moines
Dubuque
Sioux City
Waterloo

KANSAS
Topeka

KENTUCKY
Louisville

LOUISIANA
Alexandria
Shreveport

MANITOBA
Winnipeg

MICHIGAN
Adrian
Frankenmuth
Grand Rapids
Kalamazoo
Otsego

MARYLAND
Wagerstown

MINNESOTA
Duluth
Hastings
Owatonna
Rochester

MISSOURI
Kansas City
St. Louis
Springfield

NEBRASKA
Omaha

New JERSEY
Bridgeton
Middlesex
New Brunswick

NEW MEXICO
Alburquerque

NORTH CAROLINA
Charlotte
Durham
Greensboro
Monroe
Winston-Salem

OHIO
Archbold
Bedford
Cincinnati
Circleville
Findlay
Hamilton
Lewistown
Mansfield
Medina
Middleton
Newark
Sandusky
Steubenville
Toledo
Zanesville

OREGON
Eugene
Portland
Salem

PENNSYLVANIA
Chumbersburg
Pittsburgh
Williamsport
York

TEXAS
Dallas
El Paso
Lubbock

VIRGINIA
Hampton Roads
Norfolk
Richmond
Winchester

WASHINGTON
Tacoma

WISCONSIN
Chippewa Falls
Madison

These figures should be taken with a degree of skepticism. From our own inquiries, it appears that in some cities the surcharge on sewage strength exists only in the statute books, and is not actually being implemented. In spite of our streneous efforts we were able to identify only 51 cities which had a surcharge in operation by the end of 1971. However, from our inquiries it is clear that the number of cities with a surcharge system is increasing rapidly. We identified 20 cities which had introduced a surcharge in 1972 or 1973 (which was too recent to be useful for our analysis) and an additional 15 cities which plan to introduce a surcharge by early 1974. In Table IV.1 we list all those cities which to our knowledge either have a sewer surcharge system or will have one by early 1974.

There seems to be two reasons for the growing popularity of this type of charge. One is that it provides an attractive way of raising additional revenues with which to alleviate the financial pressure on public sewage systems. The other is that under the 1972 Water Pollution Control Act, the EPA now requires of cities which seek treatment plant construction grants that they charge industrial customers for their share of sewage costs. Both factors are likely to continue to operate, which leads us to expect that excessive strength surcharges will become very much more common in the near future.

IV.2. Data Collection

We obtained information in which cities have, or might have, sewer surcharges from several sources. First we got information from personal communication from Professor Jack Johnson of McMaster University, who has studied urban sewer service charges, and from Mr. Louis Guy of the Water Pollution Control Federation. We conducted telephone surveys of State Water Pollution Control Agencies in about 10 states. We also used a recent Ph.D. thesis by Ralph Elliott at the University of North Carolina, who studied the response of firms to sewer surcharges up to 1970, using a somewhat different methodology form that employed in this study. In addition we consulted a survey of municipal sewer service charges published by the American City Magazine. From these sources we assembled a list of about 95 cities which were believed to have sewer surcharges in operation. A telephone call was made to the sewer departments of each of these cities to inquire whether there actually was a surcharge system in force and, if so, to ascertain some details of its operation. (The short questionnaire used in these telephone interviews, together with all the survey instruments used in this project, is shown in Appendix IV.A).

For cities that did have a surcharge in operation before 1972, a letter was sent to the appropriate official describing the objectives of our study and asking for his assistance in completing a questionnaire. The questionnaire was in three parts. The first dealt with the details of the surcharge system; the second asked for dates on the volume of sewage flow, the amount of surcharge payment, and the amount of pollutants discharged by each firm paying a surcharge in each year since the introduction of the surcharge system. We also asked for a brief description of the industries in which the firms were located and, where permitted, their names and addresses.

The last part of the questionnaire dealt with the administration of the surcharge and the city official's evaluation of its effectiveness.

The questionnaire asks for information on individual firm discharges which is technically in the public domain, insofar as it belongs to local government agencies, but which is often regarded as confidential by private firms. As a result, to encourage responses, we guaranteed to preserve the confidentiality of the data and to refer to the cities and firms involved in this study by code numbers, so that the individual firms on which we have data could not be publicly identified. In accordance with this promise, we will not identify the individual cities and firms in this report, instead we will refer to cities by a 3-digit code, ranging from 011 to 204, and to firms by a 2-digit code, ranging from 01 to 70. Thus firm 05139 is firm number 39 in city number 051.

In the light of the telephone survey, questionnaires were sent to 51 cities which were known to have surcharge systems in operation prior to 1972. About ten days after the making of the questionnaire, follow-up phone calls were made to ensure that the questionnaires had arrived safely and to check whether there would be any problems in obtaining the data. In most cases, further phone calls were made a few weeks later to check on progress in dealing with the questionnaire. This was repeated, where necessary, until mid-September. This has resulted in responses from 31 cities, containing data on firm waste discharges from as far back as 1955, and as recent as 1971, through 1972 (in some cases, through mid-1973).

For various reasons, to be discussed in the next section, not all of this data was suitable for analysis and we have ended up with a potentially useful data set covering 21 cities.

Considering the substantial amount of work required of city officials in compiling time series data on waste discharges by individual firms, the response rate is highly satisfactory. It was made possible by the generous interest of many local government officials, who must perforce remain anonymous. We must emphasize that the data which they supplied to us was not usually easily accessible. Because of their efforts we have been able to obtain a large and unique body of micro-data on industrial waste discharges of very good quality.

The cities in our sample seem to be well representative of the cities in which excess strength surcharges are in operation. The non-respondents fall mainly into two categories: small cities in rural areas with a relatively small number of firms paying a sewer surcharge; and a few large cities with very many firms paying a sewer surcharge, but with a poor record keeping system.[3] Fortunately however, there were other cities with many firms paying a surcharge which had a good record keeping system or, as happened in several cases, found it to be in their own interest to compile the data which we were seeking. The cities in our sample offer a variety of sizes and geographical locations. The distributions of these variables are shown in Tables IV.2, IV.3.

In the course of analyzing the data which we had collected, we became convinced of the need to obtain data on individual firm output levels covering the time period for which we had data on individual firm waste discharges and of a comparable quality in its detail. The available published data, such as the annual censuses of manufacturing, did not

TABLE IV.2 SIZE DISTRIBUTION
OF CITIES IN SAMPLE

Population Range	# Cities
<25,000	4
25,000 - 100,000	7
100,000 - 200,000	7
200,000 - 400,000	1
400,000 - 600,000	2

TABLE IV.3. GEOGRAPHIC DISTRIBUTION OF CITIES IN SAMPLE

Region	# Cities
South Atlantic	7
East North Central	8
East South Central	1
West North Central	2
Pacific	3

cover separately all the cities in our sample. It also only runs as far as 1971, and is much too highly aggregated in comparison with our plant-by-plant data on waste discharges. Therefore we decided to send a questionnaire to all the firms in our sample requesting data on their output since the introduction of the surcharge and also asking them to describe their response to the surcharge, as a check on the validity of the inferences we have drawn from our data. The questionnaires were sent out too late to be used in the present study, but the initial response of firms seems to be very good and we are hopeful of obtaining a good set of output data which can be matched up with our wast discharge data in future research.

Thus, for the purposes of this project, our data consists of the following variables for each firm:

FLO: The annual volume of sewage discharges (in million gallons, or million cubic feet)

BOD: The number of pounds of BOD discharged annually

SS: The number of pounds of SS disharged annually

CBD: The average annual concentration of BOD in sewage discharges (in ppm)

CSS: The average annual concentration of SS in sewage discharges (in ppm)

PBOD: The charge in dollars per 1000 pounds of BOD discharged in excess of the permitted waste concentrations.

LIMB: The concentration of BOD (in ppm) above which the surcharge on BOD is levied

PSS: The charge in dollars per 1000 pounds of SS discharged in excess of the permitted waste concentration

LIMS: The concentration of SS (in ppm) above which the surcharge on SS is levied

PFLO: The flow sewer service charge, in dollars per 10,000 gallons of sewage discharge

SIC: The 3- or 4-digit category describing the industry in which the firm is located

SIZE: A dummy variable, taking the value 0 for small firms and 1 for large firms (explained below)

The variables FLO, BOD, SS, CBD, CSS are in the form of time series for each firm, sometimes of unequal length for different firms in the same day. They were formulated on an annual basis to circumvent the problem of seasonal variations in waste discharges which is a characteristic feature of some of the industries in our sample (for example food processing). There were some exceptions, however. In one case the sewer surcharge was applied on the basis of waste discharges in the month with the highest waste concentration; there the variables BOD, SS, CBD and CSS were taken to refer to the highest month in each year. In another case, the raw data received from the city consisted of the results of tests of BOD and SS concentration at many different times throughout the year, ranging from about 10 tests in some years to about 60 in others. Since most of the industries involved were highly seasonal in operation, we standardized the data by computing the average wast concentration within the busy season of each year, and used that for our time series on CBD and CSS.

Not all the cities levy charges on both BOD and SS and hence they do not all have data on both sets of variables, BOD and CBD, and SS and CSS. Also, in some cities the data on FLO was unavailable (usually because it was recorded by some other municipal agency than the sewer department to which we had written) and only the data on CBD and/or CSS was available.

Hence there are gaps in the coverage of our data on FLO, BOD, SS, CBD, and CSS. Finally, it should be noted that a few cities monitor other waste parameters besides BOD and SS, such as pH, grease and COD. However, our data on these other variables is so sparse that we decided to omit them. Table IV.4 shows the coverage of our data.

In several cases firms had responded to the charge on waste strength by reducing their discharges so much that they were no longer required to pay the surcharge. In some of these cases the city would cease to monitor their discharges and the data time series would end prematurely. In these cases, in the absence of other information, we made the conservative assumption that these firms' waste concentrations were just equal to LIMB and/or LIMS (in the maximum waste concentrations at which they would avoid the surcharge), and used these values to compute the desired time series on CBD and CSS (and on BOD and SS, if we still had data on FLO).

The variables PBOD, LIMB, PSS, LIMS and PFLO are, of course, common to all the firms in each city.[4] In a few cases these variables were changed during the period for which we have data (i.e. since the introduction of the surcharge). The method by which we dealt with these cases will be explained below. The information on SIC code was obtained either directly from the city officials who filled out the questionnaire or by reference to the SIC Handbook. In addition we consulted Key Plants 1970-71, a publication of Market Statistics Inc. of New York which lists more than 41,000 plants throughout the U.S.A. with 100 or more employees in 1970 and dientifies their address, SIC category and employment size. Every city in our sample is included in this directory. We assumed, with very few

Table IV. 4 DATA COVERAGE

INDIVIDUAL VARIABLES	# OBSERVATIONS
DFLO	190
DBOD	157
DSS	178
DCBD	186
DCSS	189

COMBINATIONS OF VARIABLES	# OBSERVATIONS
DFLO, DBOD, DCBD	12
DFLO, DSS, DCSS	33
DFLO, DBOD, DSS DCBD, DCSS	145
DCBD, DCSS	11
DCBD	18
TOTAL	219

exceptions, that if a plant was excluded from the directory it must employ less than 100 workers. Most of the firms in our sample which were included in the directory employed between 100 and 400 workers; the largest recorded employment (for a tobacco company) was 2,500. Because of the peculiar range of our data on plant employment we decided to classify firms into two groups,those with a labor force of less than 100 (SIZE = 0) and those with a labor force of 100 or more (SIZE = 1).

The firms in our sample covered a fairly wide range of different manufacturing industries, and one important service industry - laundries (SIC 721). We also had about 15 observations on waste discharges from public institutions, such as hospitals, prisons and universities; we chose to exclude this data. For the rest, we grouped the industries into 9 categories, as follows:

1. Heat and Poultry Processing
2. Dairy Products
3. Canned and Preserved Fruits and Vegetables
4. Miscellaneous Food Processing
5. Textiles
6. Tobacco
7. Paper
8. Miscellaneous Manufacturing
9. Laundries

The details of this classification in terms of standard SIC categories are shown in Table IV.5. In the rest of this report, the variable SIC will refer exclusively to our broad classification of industries (i.e. it will take on values from 1 through 9). It should be noted that the Directory

Table IV.5

INDUSTRIAL CLASSIFICATION

Study Category	Standard Industrial Classification Category
1	201
2	202
3	203
4	204, 205, 206, 207, 208, 209
5	21
6	22
7	26
8	2751, 2752, 281, 283, 286, 1381, 3111, 3221, 3275, 3321, 3442, 3452, 3471, 3479, 3573, 3662, 369, 374, 401
9	721

of Key Plants, on which relied for our information on plant size, does not cover service industries such as laundries. We made the plausible assumption that none of the laundries in our sample was likely to employ more than 100 workers, and therefore we set the value of SIZE at zero in their case.

IV.3. Methodology

Given our data we faced the problem of how to make inferences from it as to the effects of the introduction of the surcharge system. In the absence of information about other features of the firms in our sample, our model postulates that waste discharges are determined by the sewage flow and surcharge prices which firms face, the type of product they produce, and their output level, on which we unfortunately had no data at the time. The response to the surcharge can be measured in five ways, namely, the responses of FLO, BOD, SS, CBD, and CSS. We shall examine these in turn.

In all cities the surcharge can be reduced to a common formula, giving the total charge for sewerage services,C,as a function of FLO, BOD, SS and the parameters of the change system;

$$C = (FLO \cdot PFLO) + (BOD - LIMB \cdot FLO \cdot K)PBOD + (SS - LIMS \cdot FLO \cdot K)PSS$$

where, to repeat, FLO in sewage flow in units of 10,000 gallons, PFLO is the volume charge in dollars per 10,000 gallons. BOD is the discharge of BOD in units of 1,000 pounds, PBOD is the charge per excess 1,000 pounds of BOD, LIMB is the allowed concentration of BOD in ppm above which the charge is levied (and similarly for SS, PSS and LIMS), and K is a conversion factor from water volume, in units of 10,000 gallons to water weight in billions of pounds. This expression may be rewritten as:

$$C = (FLO \cdot PFLO) + (BOD \cdot PBOD) + (SS \cdot PSS) - (LIMB \cdot K \cdot PBOD) \cdot FLO - (LIMS \cdot K \cdot PSS)\ FLO$$

The term $(LIMB \cdot K \cdot PBOD) \cdot FLO$ represents the reduction in sewer payments, as a function of FLO, when compared to the charge that would be incurred if there were no allowance for normal BOD discharges (i.e. if LIMB were zero, as happens in some cities). A similar interpretation applies to the term $(LIMS \cdot K \cdot PASS) \cdot FLO$. For future reference we shall refer to the two implicit prices in these expressions as:

$$PAB \equiv (LIMB \cdot K \cdot PBOD)$$

and

$$PAS \equiv (LIMS \cdot K \cdot PSS)$$

This type of charge system introduces an interdependence between the costs of discharging an additional unit of FLO and of BOD and SS. Suppose that the firm changes to levels of FLO, BOD and SS from FLO_1, BOD_1, SS_1, to FLO_2, BOD_2, SS_2. The additional cost to the firm may be written as:

$$\Delta C = (FLO_2 - FLO_1)\ (PFLO - LIMB \cdot K \cdot PBOD - LIMS \cdot K \cdot PSS) + (BOD_2 - BOD_1) \cdot PBOD + (SS_2 - SS_1) \cdot PSS$$

Thus, if the change actually involves only a change in flow, with BOD and SS kept constant with $BOD_2 = BOD_1$, and $SS_2 = SS_1$), the marginal cost per unit flow is

$$(PFLO - LIMB \cdot K \cdot PBOD - LIMS \cdot K \cdot PSS)$$

which is less than PFLO, the conventional marginal cost of discharging an extra unit of sewage flow. Indeed this full marginal cost may even be negative if you lower BOD concentrations sufficiently. We shall refer to this adjusted marginal cost as PAM, and we have the following relationship:

$$PAM = PFLO - PAB - PAS$$

The implication of this simple algebra is that, with a surcharge system in operation, the effective cost of discharging sewage flow is lowered. Thus there is an incentive to lower the total sewerage bill not by reducing the amount of BOD or SS, but by increasing water use and sewage flow. However, we cannot unambiguously interpret an increase in the volume of sewage discharges as a maximizing response to the introduction of a surcharge system. First, sewage flow may have increased simply as a response to an increase in production, which may indeed also have caused an increase in the discharge of BOD and SS. Second, given the stimulus of the new surcharge system firms may have responded by recycling wastewater or by changing their production techniques in such a way as to reduce their consumption of water.[5] In the first case, presumably one would not wish to count the outcome as a success for the surcharge system, and in the second case, where the outcome involved a reduction in sewage flow one would wish to count it as success for the system.

The response of BOD and SS provide somewhat more unambiguous criteria for judging the success of the surcharge system. Even here, however, there are still some complications. Firstly, BOD (or SS) may have increased because output has increased, although less than proportionately because of the surcharge. It would be wrong to classify this as an example of the failure of the surcharge but, since we do not yet have data on firm output, that is a risk which we must take. Secondly, for reasons which we still do not understand, BOD and SS have sometimes changed in opposite directions.

This did not happen in the majority of cases, but it did occur in a modest number of cases.[6]

Finally, a successful surcharge system should cause a reduction in the concentration of BOD and SS. In this case, unless water input and pollutant output are highly different functions of output, it whould not matter too much that we have no data as yet on firm output levels. The only complication is the case where the firm responds to the surcharge by reducing water use so extensively that the flow discharge declines disproportionately more than the output of pollutants, and hence the concentrations of BOD and SS actually rise.

In order to implement these criteria for judging the success of the surcharge system we had intended to perform a large number of different types of statistical analysis. Unfortunately, because of dealys in receiving the data from the cities, the unsuitability of the statistical programs at the Harvard Computer System for dealing with data that was both time series and cross section (i.e. many different firms, each over several years), and the delays and expenses in debugging the more sophisticated computer programs, we were only able to undertake two major types of econometric analysis, which we shall describe below. We shall also indicate briefly the other types of analysis which should be performed in the future.

The first test is to take the level of each firm's output of waste a short while after the introduction of the surcharge and compare it with the levels before the introduction of the surcharge or, in the absense of earlier data, with the levels in the first year of the surcharge. This ratio can be taken as a dependent variable to be regressed on the parameters of the charge system and whatever other explanatory variables are available (in this case, SIX and SIZE). This was done for each of the five variables of interest in turn (with FLO, BOD, SS, CBD and CSS).

In this model we are not strictly testing the hypothesis that a surcharge leads to a reduction in BOD etc.; rather we hypothesize that a higher surcharge rate leads either to a larger reduction in BOD or a smaller increase than a lower surcharge rate. The alternative approach is to create a dichotomous variable representing the dichotomous events that ROD did fall or did not fall (i.e. a variable which took the value 1 of BOD fell and the value 0 of it did not fall) and to explain this variable in terms of the parameters of the charge system, SIC and SIZE. There are various statistical techniques which can be applied to this type of classification analysis. Because it requires only a standard regression program we chose the linear probability model for this analysis.

As we shall explain below, this method of estimation turned out to work rather poorly with our data (which could not have been predicted in advance). As between the two models -- the continuous dependent variable model versus the dichotomous dependent variable model -- we would hypothesize that the continuous dependent variable model is especially appropriate for analyzing the behavior of BOD and SS, insofar as they may be affected by the upward trend in output, on which we have no data. In principle, the two estimation techniques should be about equally desirable in analyzing the other three sets of dependent variables. The results of these analyses are described in the next section.

However, we should mention that there are two other ways of looking at our data and making inferences about the effect of the surcharge system. One approach is to look at the time pattern of the response to the surcharge system and to inquire whether that too is affected by the charge system. Thus, for example, one could regress FLO, BOD, SS, CBD, and CSS separately as some (nonlinear) function of time, and then test whether the fitted parameters of that function vary among firms systematically as a function of the charge parameters, and SIC or SIZE.

The second approach is to look at the absolute levels of FLO, BOD, SS, CBD and CSS after firms are presumed to have adjusted to the surcharge, and to test whether these levels vary systematically among firms as a function of the charge parameters and the other explanatory variables. Although we would like to experiment with their approach, we have some doubts as to its success. We do not have too much confidence a priori in the underlying assumption that two different firms in the same industry, and even producing the same output level, would necessarily have the same volume of sewage flow, discharge the same amount of pollutants or have the same waste concentration when facing the same sewer charges. We suspect that differences in plant technology and age may cause firms in the same industry to have rather different levels of water use and pollutant discharge, even though their relative response to sewer surcharges maybe similar. However this remains an open question.

We should mention that the two modes of analysis which we have just outlined need not be performed separately. They could be combined rather elegantly by first fitting a logistic function to time series data on FLO or BOD etc., or some other function such as the reciprocal function, and then regressing both the fitted rate-of-decline parameters of these functions and the fitted lower asymptotes on the charge parameters and any other explanatory variables. Delays in deseasonalizing the time series prevented our completing this study. However, our preliminary judgment is that this approach too may not be successful because of differences in the type of time response function exhibited by different firms. This makes it difficult to find a common functional form which suits the data from a large enough number of firms to provide a basis for comparison.

IV. 4. Statistical Analysis

As was mentioned earlier, we have obtained data on firms in 31 cities in 12 states. For the cross-section analyses described in the previous section we discarded the data from 10 cities, for a variety of reasons. In some cases surcharge system had not been properly implemented until too recently to be of use. In other cases the system had been introduced so long ago (in the early 1950's) that we considered the response of firms at that time to provide very little information given the purposes of our investigation. In yet other cases the charge had been in operation for a long time - at least 10 years - before the commencement of the time series data that we obtained. This obviously precluded an analysis in terms of the before-after response. Finally, in some cases firms were being charged on the basis of some parameters which were irrelevant to our model (i.e. poultry producers charged on the basis of the number of chickens billed). Most of the cities which we discarded were small and had few firms paying the surcharge.

In order to implement the model we needed to know the levels of FLO, BOD, SS, CBD and CSS prior to the surcharge and after the firms had adjusted to it. With two exceptions we had no data for the period prior to the introduction of the surcharge, and therefore, we were compelled to take the values of these variables in the first year of the surcharge as a surrogate. Insofar as firms have adjusted to the surcharge within the first year of operation (or even in anticipation of its introduction) our data will understate the true response. Furthermore, insofar as different firms in different cities or in different industries have adjusted to the surcharge to different degrees either before its introduction or in the first year of its operation, this will also bias our results. However, since most cities did not monitor waste discharges before the introduction of the surcharge, nothing can be done to overcome this problem. The questionnaire which we have sent to firms contains a question on the time lag before the firm adjusted to the surcharge, and the answers to this question will be extremely useful.

Determining when each firm might be said to have adjusted to the surcharge was by no means simple. In general we adopted the policy of taking the third or fourth year of the surcharge as the "after" year, in which to measure firms' responses. We varied that rule when it led to manifestly misleading results. In several cases, where We had a relatively long time series with fluctuations, we averaged over two or three years (say the third, fourth and fifth years of the surcharge). Finally, in some cases we had very short time series of only two years length (i.e. the surcharge was introduced in 1971 and we had data for 1971 and 1972), in these cases we took the first year as representing the "original" situation and the second year as representing the response. This may not have been an unreasonable assumption, because the data does seem to indicate that in cities which introduced surcharge more recently (say since 1969) the response of firms has been swifter than in cities which introduced a surcharge earlier. This seems to be true independently of the size of the surcharge.

In four cities for which we had fairly long time series data (of six years or more) the surcharge rates had been changed during the period covered by our data. In two cases, cities 133 and 165, the change had occurred about 6 or 7 years since the introduction of the surcharge system and data clearly showed an initial response to the original surcharge (in terms of a reduction in BOD etc.) which was then gradually reversed until the change in the surcharge rates. At that time a new response was manifested. In these cities we recorded two observations for each firm, one representing its response to the original charge and the other its response to the later charge. This second set of observations were indexed 134 and 166, respectively. In two other cases, cities 113 and 111, the surcharge rates had been changed after only three years. In these cases we

Table IV.6 DISTRIBUTION OF FIRM SIZE BY INDUSTRY

		INDUSTRY									
		1	2	3	4	5	6	7	8	9	TOTAL
SIZE	Under 100 emp.	18	13	10	16	0	3	6	16	43	125
	More than 100 emp.	13	18	11	17	6	13	7	9	0	94
	TOTAL	31	31	21	33	6	16	13	25	43	219

TABLE IV.7 DISTRIBUTION OF INDUSTRY TYPES BY CITY

	Industry									
City #	1	2	3	4	5	6	7	8	9	TOTAL
011	3	2								5
021	2	1	5	4		1	3	11	6	33
023	5	4	6	1				1	1	18
024			3							3
041	2	1		4						7
051	1	4	3	13					4	25
071			1	1						2
111				1						1
112	2			2					4	8
113							4	2		6
115							3	2		5
133	5	7	1	2				2	3	20
134	4	5	1	2				2	3	17
141		1	1			2		3		7
152	1	3			2	2			15	23
153	3	1		2	1	3		2	1	13
154	2					4				6
155	1	2		1	3	4			6	17
165							3			3

again created two sets of observations, taking the response in the third year versus that in the first year for the first observation, and the response in the sixth or seventh year versus that in <u>the first year</u> as the second (indexed 114 and 117, respectively). In all these cases, the price variables for the second set of observations was taken to be the absolute level of the new charge, rather than its increment over the original charge.

With these adjustments we had 21 sets of observations on 219 firms, including the imaginary cities 134, 166, 114 and 117 (without them we would have had 33 less data points).[7]

This data is reproduced in Appendix IV. B. It includes the code numbers for each firm and each city, and the values of SIZE and SIC, and of DFLO (the ratio of sewage flow in the response year to that in the initial year), DBOD, DSS, DCBD and DCSS (the similar ratios pertaining to BOD, SS, CBD and CSS, respectively) and the miscellaneous price variables (PFLO, PBOD, LIMB, PSS, LIMS, PAB, PAS, and PAM). The distribution of firm sizes and industries is shown in Tables IV.6 and IV.7.

The distributions of the values of the variables DFLO through DCSS are shown in Table IV.8. This table provides a check on the validity of our proposed binary classification of these variables. It would seem to imply that the variables DBOD, DSS, DCBD and DCSS can reasonably be classified into two categories - increase versus decrease - but in the case of DFLO there remains some doubt as to whether one should create a third category representing "no change"; if this category were defined as covering the range of values from DFLO = 0.90 to 1.10 it would account for 28.9% of the observations. However the argument for creating a third

TABLE IV.8 DISTRIBUTION OF RESPONSES

Percent of Cases in Each Interval

Interval	DFLO	DBOD	DSS	DCBD	DCSS
$\leq$ 0.8	20.5	31.2	37.6	34.4	37.0
0.8 0.9	9.5	4.5	5.6	8.6	7.0
0.9 0.95	6.3	3.8	1.7	4.3	4.8
0.95 1.0	7.4	2.5	3.4	2.2	3.7
1.0 1.05	10.5	6.4	0.6	3.8	3.7
1.05 1.10	4.7	1.3	1.1	5.4	3.2
1.10 1.20	10.5	5.1	5.6	6.5	3.7
> 1.2	30.5	45.2	44.4	34.9	36.5
$\leq$ 1.05	54.2				
> 1.05	45.7				
< 1.0		42.0	48.3	49.5	52.9
$\geq$ 1.0		58.0	51.7	50.5	47.1
Number of Observations	190	157	178	186	189

TABLE IV.9 DISTRIBUTION OF DBOD BY DSS

		DBOD	
		< 1.0	≥ 1.0
DSS	< 1.0	40	25
	≥ 1.0	23	57

(number of cases
in each cell)

category is not conclusive. For convenience, we decided to continue with the binary classification, but to modify it by counting only values of DFLO greater than 1.05 as an increase in flow. In so doing we effectively discount small changes in sewage flow possibly associated with the steady growth in output.

Another interesting question concerns the correlation between changes in the discharges of BOD and of SS. In the pooled data there is a positive correlation between DBOD and DSS -- the correlation coefficient is 0.3742; this is their joint distribution as shown in Table IV.9, and according to the standard X^2 test, the hypothesis of mutual independence can be rejected at the .01 level. However, if one groups the data according to industries the results are somewhat different; the hypothesis of independence can be rejected for the meat processing, textile, paper and laundry industries (in all these cases there was clearly a positive correlation), but not for the dairy, canning, miscellaneous foods, tobacco and miscellaneous manufacturing industries.

The variables which we used in our regression equations are shown in Table IV.10. Some of the dependent variables have already been explained; the rest will be introduced and explained below. The independent variables are firm size, industry type and the various parameters of the charge system.

TABLE IV.10

KEY TO VARIABLES USED IN REGRESSION ANALYSIS

A. Dependent Variables

DBOD	The ratio of discharge of pounds of BOD at a time 2-4 years after the introduction of the surcharge to the discharge in the year before the surcharge, or in the first year of the surcharge.
DSS	Similar ratio for SS.
DFLO	The ratio of sewage flow at a time 2-4 years after the introduction of the surcharge to the flow in the year before the surcharge, or in the first year of the surcharge.
DCBD	The ratio of the concentration of BOD in ppm at a time 2-4 years after the introduction of the surcharge to the concentration in the year before the surcharge, or in the first year of the surcharge.
DCSS	Similar ratio for the concentration of SS.

DUMBOD	=	1 if DBOD < 1.0 0 otherwise
DUMSS	=	1 if DSS < 1.0 0 otherwise
DUMFLO	=	1 if DFLO > 1.05 0 otherwise
DUMCBD	=	1 if DCBD < 1.0 0 otherwise
DUMCSS	=	1 if DCSS < 1.0 0 otherwise
TOBBOD	=	DBOD if DBOD < 1.0 0 otherwise
TOBSS	=	DSS if DSS < 1.0 0 otherwise

Table IV.10 cont.

A. Dependent Variables (cont.)

TOBFLO	=	DFLO if DFLO > 1.05 0 otherwise
TOBCBD	=	DCBD if DCBD < 1.0 0 otherwise
TOBCSS	=	DCSS if DCSS < 1.0 0 otherwise

Table IV.10 cont.

KEY TO VARIABLES USED IN REGRESSION ANALYSIS

B. Explanatory Variables

SIZE		An index of firm size, takes value 1 if firm employs more than 100 workers, 0 otherwise.
SIC		Industry in which firm is located (See Table IV.5 for details).
PFLO		Sewerage service charge pertaining to flow (in $ per 10,000 gallons per month).
PBOD		Sewerage service surcharge on discharges of BOD in excess of a given concentration (in $ per 1,000 lbs. of BOD).
PSS		Sewerage service surcharge on discharges of SS in excess of a given concentration (in $ per 1,000 lbs. of SS).
LIMB		The BOD concentration, in excess of which the BOD surcharge applies (in ppm).
LIMS		The SS concentration, in excess of which the SS surcharge applies (in ppm).
PAB	$\equiv$	LIMB x PBOD x .0000833 The implied remission of surcharge payments on BOD discharges due to the existence of a cut-off concentration, LIMB, below which the surcharge does not apply (in $ per 10,000 gallons flow).
PAS	$\equiv$	LIMS x PSS x .0000833 The implied remission of surcharge payments on SS discharges due to the existence of a cut-off concentration, LIMS, below which the surcharge does not apply (in $ per 10,000 gallons flow).
PAM	$\equiv$	PFLO - PAB - PAS The net cost (in $) of discharging an additional 10,000 gallons allowing for the savings due to the remission of surcharge payments on discharges of BOD and SS.
PAMOD	$\equiv$	max(PAM,O) The net cost of discharging flow truncated at zero.

TABLE IV.11 CORRELATIONS AMONG PRICE VARIABLES

	PFLO	PBOD	PSS	LIMB	LIMS	PAB	PAS	PAM	PAMOD	RATP	RATPOD
PFLO	1.0	0.695	-0.013	0.409	-0.365	0.728	-0.03	0.852	0.903	0.303	0.183
PBOD		1.0	-0.036	0.362	-0.479	0.989	-0.05	0.308	0.424	-0.216	-0.295
PSS			1.0	0.264	0.413	-0.002	0.952	-0.309	-0.176	-0.608	-0.619
LIMB				1.0	-0.177	0.443	0.28	0.17	0.25	-0.184	-0.249
LIMS					1.0	-0.45	0.546	-0.364	-0.407	-0.2	-0.371
PAB						1.0	-0.005	0.329	0.445	-0.215	-0.317
PAS							1.0	-0.343	-0.24	-0.583	-0.663
PAM								1.0	0.964	0.699	0.632
PAMOD									1.0	0.496	0.501
RATP										1.0	0.884
RATPOD											1.0

DEFINITIONS:

PAB ≡ PBOD × LIMB × .0000833

PAS ≡ PSS × LIMS × .0000833

PAM ≡ PFLO − PAB − PAS

PAMOD ≡ MAX (PAM,0)

RATP ≡ PAM/PFLO

RATPOD ≡ PAMOD/PFLO

The inter-correlations among these price variables are shown in Table IV.11. It is interesting to note the (weak) negative correlation between the parameters of the charge system relative to BOD and those relating to SS, and the relatively strong correlation of PFLO with the BOD price parameters. In view of these relationships, it is not surprising that PAM is related positively to the BOD variables and negatively to the SS variable.

The Effect on the Volume of Sewage Discharges

In order to examine the effects of the surcharge system on the volume of sewage discharges we conducted two types of analysis. In the first analysis, the dependent variable was DFLO, the ratio of the volume of sewage discharges a few years after the introduction of the surcharge to the volume of discharges at the time of its introduction. We first ignored the differences in response among different industries and regressed DFLO on various combinations of the price variables and SIZE using the full set of data. Some of the results are shown in TABLE IV.12. We would expect DFLO to be a negative function of PFLO, although if the same price on sewage flow had been in effect for some time before the introduction of the surcharge there would be less reason for a negative effect on DFLO in the period after the introduction of the surcharge. In general, the coefficient of PFLO is negative, though it is affected by the multicollinearity of PFLO with PBOD, PAB PAM and PAMOD.

Table IV.12 REGRESSIONS OF DFLO POOLED SAMPLE

Equation No.	Indep. Vars. / Dept. Var.	Constant	PFLO	PBOD	PSS	LIMB	LIMS	PAB	PAS	PAM	PAMOD	SIZE	$\bar{R}^2$
1	DFLO	1.522	.0679	-.009	.00135	-.000324	-.00124					.229	.056
		(7.92)	(1.0)	(2.5)	(0.25)	(0.63)	(2.25)					(2.17)	
2	DFLO	1.169	.089					-.319	-.215			.241	.044
		(10.03)	(1.28)					(2.16)	(1.03)			(2.28)	
3	DFLO	1.405	-.243			-.00006	-.0007			.285		.255	.049
		(7.83)	(1.86)			(0.1)	(1.4)			(2.0)		(2.44)	
4	DFLO	1.327	-.331			-.00007	-.00053				.487	.237	.059
		(7.61)	(2.32)			(0.88)	(1.15)				(2.46)	(2.27)	
5	DFLO	.747	-.0886								0.352	0.426	.121
		(9.22)	(0.77)								(1.93)	(4.06)	

Note:: The absolute value of the t-coefficient is given in parentheses below each coefficient.

Insofar as the surcharge system provides an incentive for dilution of wastes,the coefficients of LIMB, LIMS, PAB and PAS should be positive; insofar as it encourages firms to re-use waste water and cut back discharges, these coefficients should be negative. Insofar as it has no effect on sewage flows, the coefficients should be zero or insignificant. Given that PFLO is already included as an explanatory variable, the coefficients of PAM or PAMOD should be negative, positive and zero, respectively, in these cases (since they are functions of the negative of the sum of PAB plus PAS).

The results which we have obtained tend to suggest that there is a response to the surcharge system, and that it takes the form of a reduction in water use rather than dilution. It should also be noted that coefficient of SIZE is uniformly positive and significant (that is, the larger firms exhibited a greater percentage increase in sewage discharge) and stable in value despite the different combinations of price variables.

It must be admitted, however, that the regressions displayed in Table IV.12 do not have very much explanatory power. The reason for this may be that they aggregate firms in different industries whose response to the surcharge may in fact, be quite heterogenous. This hypothesis can be tested in several ways. In a preliminary analysis, using a subset of about 40 percent of the data, we ran regressions on DFLO adding eight-dummy variables each taking the value 1 if the firm belonged to a particular industry and 0 otherwise. The results of these regressions were discouraging; most of the dummy variables had zero coefficients. However, this experiment is merely an explicit test of the hypothesis that the separate industry equations have different constant terms (i.e. different 'natural' rates of increase in sewage flow) but the same slope coefficients (i.e. the same response to the surcharge variables).

Therefore, we decided explicitly to run separate regressions of DFLO for the observations in each of the nine industry categories. For this purpose we chose a simple equation in which the explanatory variables were PFLO, PAMOD and SIZE. The results are shown in Table IV.13. The first row of that table repeats the results obtained when the same equation is fitted to the data aggregated over all industries. It was unwise to include SIZE in this experiment because it so happens that in industry 5 (textiles) all the firms are large and in 9 (laundries) all the firms were classified as small. Hence in regression 5 we were loading a vector of 1's which were collinear with the constant term and effectively pushed it out, and in regression 9 we were loading a vector of 0's which made the data matrix singular and prevented the calculation of the regression coefficients for that equation.

The results of the separate industry regressions are quite remarkable. The vast improvement in explanatory power - even when corrected for differences in the degrees of freedom -- shows how unwise it is to throw firms from different industries into a common sample. In the absence of a regression equation for sector 9 it is impossible to make a formal test, but for any plausible assumption as to the value of the sum of squared residuals from that equation one would reject the hypothesis

Table IV.13 REGRESSIONS OF DFLO, SEPARATE INDUSTRIES

Sic	Indep. Var. / Dep. Var.	Const.	PFLO	PAMOD	SIZE	$\bar{R}^2$	No. OBS
1	DFLO	.0304	.49	.16	.232	.56	
		(1.57)	(4.96)	(0.95)	(1.71)		21
2	DFLO	.0259	0.49	-.288	.614	.632	
		(1.88)	(4.02)	(1.37)	(8.87)		23
3	DFLO	.0142	0.8	-.47	.574	.667	
		(1.63)	(11.43)	(3.99)	(10.23)		15
4	DFLO	.0544	.799	-.558	.524	.409	
		(2.05)	(4.95)	(2.0)	(3.76)		32
5	DFLO	0	-.215	.522	.711	.833	
		(0.0)	(5.83)	(4.7)	(6.21)		6
6	DFLO	(.0035)	-.305	.922	.804	.324	
		(0.12)	(1.51)	(3.66)	(3.18)		16
7	DFLO	.001	3.314	-.642	.527	.832	
		(0.1)	(12.57)	(2.46)	(6.32)		13
8	DFLO	.0533	-.136	.651	1.17	.409	
		(2.36)	(0.56)	(1.64)	(8.98)		23
	DFLO	.747	-.086	.352	.426	.121	
		(9.22)	(0.77)	(1.93)	(4.06)		190

that the coefficients of the individual equations are the same as those of the pooled regression, at the 90 percent confidence level. In most industries the coefficient of PFLO is positive and very significant. This is somewhat surprising and requires further investigation. We shall suggest a possible explanation below. The effect of the surcharge system is shown by the coefficients of PAMOD. The results suggest that in industries 2 (dairies) 3 (canning) 4 (miscellaneous food manufacturing) and 7 (paper) the response is dilution while in industries 5 (textiles) 6 (tobacco) and 8 (miscellaneous manufacturing) the response is a cut-back in water use and sewage discharges. In industry 1 (meat processing) there does not appear to be any response of sewage flow to the surcharge system. Finally, SIZE continues to have a significant positive effect on the growth of sewage discharges.

The second type of analysis which we performed was an application of the linear probability model. In this analysis, the model is cast in terms of whether or not a particular event occurred--in our case whether sewage discharges grew by more than 5 percent. We create a dependent variable,called in this case DUMFLO, which takes the value 1 of the event occurred, and 0 otherwise. There are several techniques for statistically explaining a dichotomous dependent variable of this type. One long used in biological essay is PROBIT analysis. Another method is simply to regress the dependent variable on the independent variables; this is the so-called linear probability model. This technique, which has been quite frequently applied by economists, has the advantage of easy computability. But it has certain conceptual weaknesses. In particular, the nature of the dependent variable implies that the regression model violates the assumption of homoscedasticity. This does not bias the fitted coefficients, but it leads to inflated and inefficient estimates of the variances of the coefficients, and hence to misleadingly low "t" values.

This can be overcome by the application of Generalized Least Squares estimation, which may be thought of as ordinary least squares applied to transformed variables, where the transformation depends upon the variance of the random error term. In practice the regression is performed in two steps. In the first step, ordinary least-squares is performed on the untransformed variables. The estimated residuals from this regression are used to form an estimate of the variance of the disturbance term. The data is then transformed through multiplication by the vector of the inverse of the square roots of these variance estimates and and ordinary least-squares is performed on the transformed data. The improvement in performance of regression equations estimated by this two-stage process is striking: the estimated variances of the coefficients are often reduced by a factor of 5 or more, and the "t" value is correspondingly increased.

However, the linear probability model, does not constrain the predicted values of the dependent variable to be in the range of 0 to 1. The practical implication of this is that one may obtain a negative number for the estimated variance of the disturbance term. This leads to a variety of computational difficulties. Unfortunately, we were not able to obtain correct results in the limited time available.

With this introduction we present the results of the linear probability technique as applied to DUMFO (pooled sample) in Table IV.14 These results are moderately consistent with those of Table IV.12. The coefficient of PFLO is generally negative (a higher price produces a lower probability that discharges will increase more than 5 percent), and the surcharge variables also tend to have coefficients which imply a reduction in sewage flows.

In the context of the linear probability model we can explore a more complex hypothesis, known as TOBIT analysis. The purpose of this analysis is to analyze an event in terms of both dichotomous and continuous variables. It answers two questions together: does a change occur and, if so, how much of change is there? Having performed the preceding analysis one then selects only the observations for which flow increases and regresses the amount of the increase (given by DFLO) on the explanatory variables. This can be implemented by running a regression with the dependent variable TOBFLO, which is defined as being equal to DFLO when DFLO exceeds 1.05 (i.e., flow increases) and zero otherwise. The results of this regression, for the pooled data, are shown in Table IV.15.

The best results with TOBFLO as dependent variable are obtained in equation 3. This shows that, when one restricts one's attention to the cases in which an increase in sewage discharges occurred (in excess of 5 percent), that firm size has no effect on the amount of the increase. Further, the cost of sewerage (PFLO) had a significant negative effect.

Table IV.14 REGRESSIONS OF DUMFLO, POOLED SAMPLE

#	INDEP. VAR / DEP. VAR	CONST	PFLO	PBOD	PSS	LIMB	LIMS	PAMOD	SIZE	$\bar{R}^2$
1	DUMFLO	.536	-.0126	-.00362	.00048	.00014	-.00034		.152	.035
		(5.76)	(0.38)	(2.08)	(0.18)	(0.56)	(1.29)		(2.95)	
2	DUMFLO	.455	-.0869					.0749	.168	.032
		(9.61)	(1.56)					(0.87)	(3.3)	
3	DUMFLO	.49	.0046	-.0034		.00017				.015
		(9.82)	(0.14)	(2.33)		(0.78)				
4	DUMFLO	.518	-.042		.0012		-.00007			.000
		(6.05)	(1.56)		(0.5)		(0.29)			

Table IV.15 REGRESSIONS OF TOBFLO, POOLED SAMPLE

#	INDEP. VAR / DEP. VAR	CONST	PFLO	PBOD	PSS	LIMB	LIMS	PAMOD	SIZE	$\bar{R}^2$
1	TOBFLO	2.085	0.188	-.0121	.0027	-.00109	-.00176		.163	.064
		(6.4)	(1.54)	(1.26)	(0.26)	(1.04)	(1.9)		(0.87)	
2	TOBFLO	.6888	.0989			-.00154	.001		.210	.049
		(7.88)	(0.89)			(1.74)	(1.22)		(1.13)	
3	TOBFLO	1.543	-0.54					0.984	.139	.092
		(8.37)	(2.46)					(2.98)	(0.75)	

But the surcharge system provided a significant positive incentive to increase discharges more (i.e., dilution). One can synthesize the results of Tables IV.12, 14 and 15 by saying that the surcharge system does not have a very strong effect on whether or not discharges actually change, but in general, it tends to have a negative influence (i.e., if discharges decrease, they decrease more where the surcharge rates are higher). However, in those cases where discharges increase, the system has a significant positive effect (they increase more where the surcharge rates are higher). These three analyses together imply that the response of sewage flows to the surcharge is significantly non-linear.

These results all pertain to the pooled data. We also performed the linear probability analysis on the data for separate industries--the results are shown in Table IV.16. These results again show the heterogeneity of industry responses and, as in all the remaining analyses, one can formally reject the assumption of homogeneous regression coefficients for all industries at the 90% confidence level. In this and the other applications of the linear probability model we eliminated industry 5 (textiles) because of the very small number of observations, and included it in 8 (miscellaneous manufacturing).

In these equations the regression coefficients strongly confirm our a priori expectations. The coefficients of PFLO are generally negative--a higher sewage flow charge leads to a smaller probability that sewage flows will increase. The coefficients of PAMOD generally support the findings of the regressions in Table IV.13 as to which industries respond by cutting back sewage flows and which respond by dilution.

TABLE IV.16 REGRESSIONS OF DUMFLO, SEPARATE INDUSTRIES

SIC	INDEP. VAR. / DEP. VAR.	CONST.	PFLO	PAMOD	$\bar{R}^2$	#OBS.
1	DUMFLO	.585	-.266	.624	.036	
		(3.75)	(1.46)	(1.84)		21
2	DUMFLO	.951	-.457	.379	.262	
		(8.63)	(2.4)	(1.2)		23
3	DUMFLO	.413	-.0122	-.0092	.000	
		(2.49)	(.05)	(0.03)		15
4	DUMFLO	.354	-.1066	.4975	.07	
		(3.2)	(0.64)	(1.98)		32
6	DUMFLO	.62	.0159	-.167	.00	
		(2.13)	(0.09)	(0.81)		16
7	DUMFLO	-.627	4.925	-2.475	.111	
		(0.91)	(2.15)	(2.39)		13
8	DUMFLO	.398	-.2609	0.465	.003	
		(3.86)	(1.39)	(1.47)		29
9	DUMFLO	.319	.1244	-.2485	.000	
		(3.35)	(1.13)	(1.3)		41
	DUMFLO	.524	-.109	0.1185	.007	190
		(12.16)	(1.93)	(1.36)		